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THIRD ESTATE

Though few to-day remember Hermann Goering with much sympathy, many have a secret respect for his expressed views on culture. The word culture, it appears, always made him go for his gun—a conditioned reflex of some subtlety. Culture is somehow an unsavoury word, which we associate with precocious outsiders, and those who ape them; it conjures up agonising recitals of twelve-tone music by Middle European composers, or falsetto readings of inscrutable verse with neither rhyme nor rhythm. It recalls interminable silent films about collective farms and battleships (generally seen in shortened versions lasting about five hours) and picture galleries on wet Sunday afternoons. It reminds us of people who practice one-upmanship by referring to Mr. T. S. Eliot as Tom, and brings to mind those frighteningly enthusiastic young ladies so vividly portrayed by Miss Joyce Grenfell. To many, culture is associated almost exclusively with the B.B.C.'s Third Programme. It is never associated with engineering.

Now that is rather curious. If we forget for a moment this parlour picture of the intellectual, and consider what is meant when we refer to Hittite or Etruscan culture, it becomes evident that the word has a broader significance. Here culture means the character or personality of a people expressed in the fabric they build about them. It represents their whole life, from the way they shoe their horses to the songs they sing when courting; their whole life and not just a part of it. In time to come historians will surely describe our own as a technical culture, meaning that technology was a dominant *motif* in the pattern of our lives; so why is it excluded from polite discussion, like some poor relation from across the tracks?

The sequestration of engineering is illustrated by the new pattern of sound broadcasting which the B.B.C. is gradually to introduce during the next few months. As part of the plan, the Third Programme, which has long been a most admirable vehicle for broadcasts of intellectural and cultural interest requiring sustained or concentrated attention, is to begin at eight o'clock in the evening instead of six. For the two hours made available and at different times during the day, using the same waveband, a new venture known as "Network Three" has been proposed. Network Three will carry many of the talks hitherto broadcast on the other B.B.C. networks and is intended as a forum for the specialist, whether he be angler, accountant, engineer, chess-player, water-cress grower, beer-mat collector, or any other candidate for "What's My Line?" No doubt the plan represents the only possible solution to the economic problem presented by the encroachment of television, but it also indicates an attitude of mind not entirely one with the character of our age.

To distinguish engineering from other professions and specialities may have an air of special pleading, but is it not already set apart by the peculiar demands that modern society places on the engineer? Indeed, these demands will not be met unless the intellectual standing of engineering is recognised by such vigorous young minds as are at present attracted to the arts.

But unlike philosphy, psychology, history, literature and economics, engineering may not be eligible for Third Programme status, and to reach a verdict we must determine the elusive quality required. A suitable candidate for elevation to his high estate might be defined as an activity pursued for its own sake, or becaue of its associated aesthetic or intellectual thrill. Engineering is certainly not excluded by this definition, for although it is often regarded simply as a means to practical ends, its fascination as a creative study has captured many of the most talented men; and who can say whether the delight one man discovers in a well-proportioned locomotive or gas turbine is basically different from another's pleasure "On Hearing the First Cuckoo," once the patina of picturesque association is removed?

Perhaps these arguments are not convincing, for our whole tradition of life prevents us from regarding a quick-return mechanism, say, in quite the same light as Ravel's "Introduction and Allegro." It is rather as an intellectual discipline, as a mode of thinking, that engineering makes its strongest claim. In a Third Programme talk in 1955, Dr. Magnus Pyke observed that science had become an important way of thought and was probably the most important intellectual influence in modern philosophy. Such a property is not limited to pure science. Thus the concept of feed-back and the theory of control systems are proving useful in the study of man and society. It is significant that one of the few talks presented in the Third Programme on engineering topics was Professor R. H. Macmillan's discussion of "Automatic Control."

It has been suggested that the Third Programme tends to deal rather with ideas than exposition. Engineering can claim to cover both. It has all the qualities of an intellectual discipline, and might indeed form the basis of a new humanism, in keeping with our times. In audience appeal it is no more esoteric than many subjects regularly treated in the Third Programme, and in any case the risk of dullness was among those the founders were prepared to take.

The Third Programme is more than a

form of broadcasting, it has become a criterion of value, a national and international power. No doubt the subject matter of engineering, with its plans, elevations and working diagrams, is not really suited to the sound medium, but there is certainly reason to raise it to what might metaphorically be called Third status. At its inauguration Sir William Haley, then Director-General of the B.B.C., spoke on the aims of the Third Programme as follows: "Let it demonstrate that we are not afraid to express our culture or to give our people access to the culture of others." Engineering is an essential item in our cultural life, and as such it deserves to be expressed.

* * *

Plain Words

Where should students live? It is a surprising fact that, in England and Wales last year, the proportion of university students who lived in lodgings was nearly constant irrespective of whether the university concerned was Oxford or Cambridge, London, or any other in the country. At Oxford and Cambridge, the percentage was 46·4, at London 46·5, and elsewhere 47·3.

The proportion of students, however, who were fortunate and enjoyed the privileges of living in colleges or in halls of residence, or, on the other hand, endured the mixed blessing of living at home, varied widely between institutions. At Oxford and Cambridge the proportion who "lived in" was 52·4 per cent.; at London only 18·4 and elsewhere 27·7 per cent. Those living at home were 1·2 per cent. at the two older universities, 35·1 at London and 25·0 elsewhere. In Scotland the position was somewhat different. There, 53·3 per cent. continued to reside at home, 34·2 per cent. went into lodgings and only 12·5 per cent. lived in.*

The great advantages of living in college or in hall are so well known as to require no enumeration here. The week before last, in our correspondence columns, Professor A. N. Black drew attention to the position at Southampton. There, of 837 men students, 356 (42 per cent.) were in residence in halls, and of the final-year engineers 72 per cent. are, or have been, in hall. The accommodation arrangements elsewhere, however, vary widely from this. Thus, at the University College of North Staffordshire nearly all the students reside in the college. But at the Manchester College of Science and Technology very few live other than in lodgings or at home. At the Durham colleges, three-quarters live in, whereas at King's College Newcastle only 9 per cent. are "in." In Scotland, the University of St. Andrews stands out with 43 per cent. in residence.

But for many years now it has been recognised that students should enjoy, at least during part of their sojourn at college, the benefits of living in. Some universities, Southampton for example, have for some time now set aside part of their income to this end. Others, notably the London colleges, including Imperial College, have not done so until this last year, though the possibility that they might remove themselves wholly from the confines of urban London may well have held back their plans for student accommodation.

Living at home has never been satisfactory for students and rooms in even good lodgings are only a poor substitute for living in. Now, lodgings are becoming scarce. The future expansion of the universities in many places, including Oxford and Cambridge, is dependent on the provision of further places of residence.

* The figures are taken from the University Grants Committee's last report: *University Development: interim report for the years* 1952 *to* 1956. H.M.S.O. [1*s* 3*d*.].

TALK-DOWN AT LONDON AIRPORT

AS IT WAS AND IS

More than 60,000 safe landings in bad visibility have been carried out under the ground-controlled approach system at London Airport. One of the very few catastrophic incidents following on the use of G.C.A. was the deplorable Vulcan tragedy in October last year, for which no really satisfactory explanation has emerged. Before referring briefly to the comments of Dr. A. G. Touch, who conducted a special investigation into the operation of the system following the accident, and to developments which will soon supercede the present equipment, it may be of interest to recall how the present ground-controlled approach system works.

The surveillance radar of the Southern Air Traffic Control Centre picks up incoming aircraft when they are about 100 miles from the airport. As the aircraft approach Epsom (from the south) or Watford (from the north) they are handed over by the S.A.T.C.C. director to the aerodrome approach controller in the London Airport control tower, who directs them in turn, at his discretion, on to a course towards the runway. Under instrument flight conditions, aircraft can use the ILS (instrument landing system), either with or without talk-down monitoring; alternatively, they can be brought in solely by "talk-down" on the ground-controlled approach (G.C.A.) system. When talk-down is required, the approach controller passes control of the aircraft over to the G.C.A. operators as the aircraft reaches Epsom or Watford and the pilot is then directed, verbally, over his V.H.F. radio telephone, towards the runway and on to the glide path, until he reaches a point 400 yards from the end of the runway, when he should be able to see the runway lights clearly and land visually. There is, as yet, no thoroughly proved substitute for the pilot on the final touchdown.

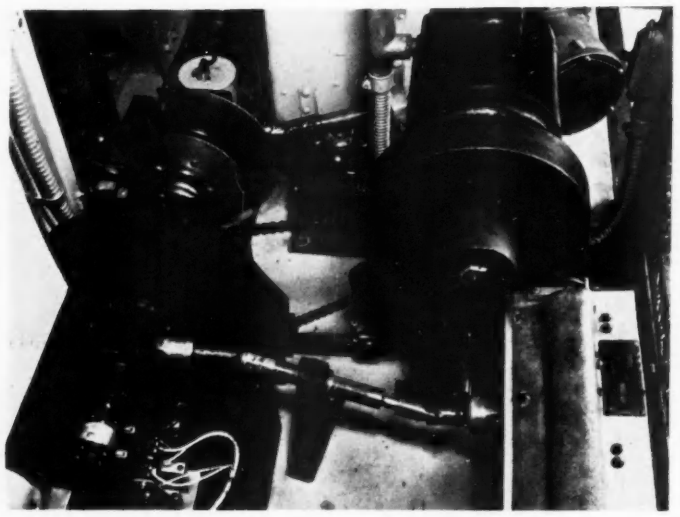

Fig. 1 The scanning drive gear for the precision radar aerials. The universally jointed shaft in the foreground drives the azimuth aerial, that seen in the background, the elevation aerial. The cam-plates on the left form a wave-guide switch which directs energy pulses alternately to each array.

Fig. 2 The interior of the ground-controlled approach (G.C.A.) truck. In the foreground is one of the search radar directors. To his left is the talk-down controller and in the background the elevation tracker.

At present, the ground-control approach equipment is housed in, and operated from a mobile truck on the airport, with direct telephone links to the control tower. The equipment, which is of American origin and war-time vintage, with some later modifications introduced by the Ministry of Transport and Civil Aviation, comprises a 10 cm. search radar with a range of 15/26 miles and a top cover of 4,000 ft., and 3 cm. precision radar for tracking the aircraft in azimuth and elevation from the "turn-on" point (about six miles off) up to the moment just before touch-down. The search radar in the G.C.A. truck is now used only as a standby; in normal practice the search radar in the control tower is used.

The truck, stationed by the side of the runway, is carefully aligned by means of a white line on the hard standing and markers on the airport, so that the precision azimuth and ele-

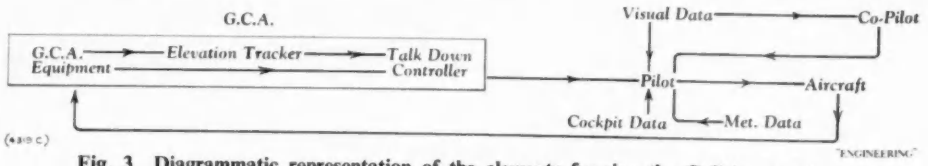

Fig. 3 Diagrammatic representation of the elements forming the G.C.A. servo-loop.

vation aerials are lined up with the approach path to the runway. The truck is also levelled by means of hydraulic jacks which take the weight of the vehicle on the ground.

Apart from the aerials and the cathode-ray tubes, the whole of the radar equipment and the four-channel V.H.F. radio-telephone sets built into the truck are duplicated. At London Airport, mains supplies are available for operating the equipment but, to guard against mains failure, the Matador lorry which hauls the truck is equipped with a Diesel-generator set. The Matador also houses air-conditioning plant for the truck.

The precision radar has two range scales—long range up to 8 nautical miles and short range up to 2 nautical miles. One transmitter serves both the elevation and azimuth precision radar aerials in turn. Scanning is carried out through a mechanical drive which also actuates a waveguide switch, by means of the two cam plates which can be seen in Fig. 1, directing radio-frequency energy alternately to each array. The elevation aerial scans through an angle from 1 deg. below the horizon to 6 deg. above and the beam width is 0·4 deg. in the scanning plane and 3 deg. in the non-scanning plane; the azimuth aerial scans through an angle of 20 deg. and gives a beam width of 0·6 deg. in the scanning plane and 1½ deg. in the non-scanning plane.

Within the truck (Fig. 2) the position of the aircraft in azimuth is displayed on the talk-down controller's long-range and short-range screens; and the position in elevation, on corresponding screens observed by a " tracker." These screens are, in fact, reflected images of the actual cathode-ray tubes, projected on to a partly silvered mirror through which is visible a map outline. The long-range displays show range-markers at 2-mile intervals, and the short-range displays at ½-mile intervals. In setting up the equipment, the innermost range markers are adjusted to pass through the touch-down point, and the range scales on the long and short-range tubes are co-ordinated. On the elevation displays, transparent cursors, used to follow the movement of the aircraft trace, are set up to correspond to a 3 deg. glide path passing through the touch-down point; and on the azimuth displays, the centre-line of the scan is aligned between four markers on the screen. The four markers comprise two pairs, one pair being situated on either side of the runway threshold, and the second pair on either side of the runway at touch-down point.

The tracker observing the elevation displays keeps the centre-line of the tracking cursor aligned on the aircraft trace by rotating a handwheel. This operation transmits information to an elevation error-meter, visible through the half-silvered mirror between the talk-down controller's two azimuth displays, showing by how much the aircraft is above or below the glide path. The tracker also informs the talk-down controller verbally when the aircraft echo crosses a range marker. The tracker keeps another reference marker continuously aligned with the aircraft echo by means of pedals, which are linked to the azimuth aerial to keep the latter in train with the aircraft; and a similar function is performed for the elevation aerial by the talk-down controller, also by means of pedals.

When the approach controller at London Airport accepts an aircraft requiring talk-down for approach from the " stack " at the Watford or Epsom radio ranges, the search radar director, after identifying the aircraft, directs the pilot on to the runway centre-line and instructs him to maintain a specified height. When the aircraft arrives within eight miles of the touch-down point, its trace comes into view on the talk-down controller's long-range screen, and at six miles the talk-down controller takes over, passing the heading and distance to the pilot and instructing him, initially, to maintain height, because at this distance from the touch-down point the aircraft is well below the 3 deg. glide path. As the aircraft comes up towards the glide path, the needle on the error-meter moves upwards and, allowing for the response lag of the aircraft controls, shortly before it reaches the zero-error position, the pilot is instructed to check undercarriage down and to descend at 500 ft. per minute. This brings him on to the glide path, and as he subsequently deviates from it he is kept informed of the amount by which he is above or below the glide path, and the heading corrections required to bring him on the glide path.

At four miles from the touch-down point, the talk-down controller signals the control-tower, by means of an amber light signal, for clearance to land; if a red light is shown, the talk-down controller instructs the pilot, at two miles, to take overshoot action. If, however, clearance is given by means of a green light, the final message to the pilot, as he approaches to 400 yards from the end of the runway, is " talk-down complete."

THE VULCAN ACCIDENT

The essence of a good talk-down lies in making allowance for the delay between observing the deviation of the aircraft from the glide path and informing the pilot, and the further delay in the response of the pilot and the aircraft as to the verbal instructions received. These lags vary with the type of aircraft, and a considerable background of experience is essential. In the " Report of the Special Investigation by Dr. A. G. Touch into Certain Aspects of the Accident to the R.A.F. Vulcan Aircraft B.I.XA.897 at London Airport, on 1st October, 1956 " (H.M.S.O.), the investigator compared the process of ground-controlled approach to a servo-loop, the elements of which are represented diagrammatically in Fig. 3. " It is . . . well known that if the various elements or linkages in a servo-loop introduce delays, the system can become oscillatory. In G.C.A. such delays do occur and become of increasing importance as aircraft speeds increase . . . it is obvious that with faster speeds of approach, the control will not be as ' tight ' and larger errors become possible."

The evidence on which Dr. Touch had to base his report was conflicting and obscure. The last recorded height information passed to the pilot was that he was 80 ft. above the glide path at about ¾ mile from the touch-down point. The talk-down controller had no recollection of the aircraft subsequently going below the glide path, and the tracker was not aware of any unusual increase in the rate of descent towards the end of approach, although a plot of the approach path deduced from the talk-down record shows that there must have been. At the inquest it was revealed that near the ground, the pilot's altimeter error was probably some 130 ft. more than he had allowed for. Dr. Touch found no evidence of any fault in the G.C.A. equipment or in its setting up, and he concluded that during the last 10 seconds the aircraft descended steeply, probably due to the build-up of oscillations about the glide path (these were revealed on the G.C.A. plot), and that the controller had failed to warn the pilot of his closeness to the ground—probably because he was concentrating too much on azimuth corrections and paying insufficient attention to the error-meter. Finally, "evidence exists to show that all the elements in the G.C.A. servo-chain were strained."

His first recommendation to prevent the recurrence of such accidents is that military aircraft of advanced design should not normally be allowed to land at civil airports unless the break-off height (i.e., the height at which the pilot decides to abandon the approach attempt) is very conservative. Among his other recommendations is a reference to modified technical equipment: ". . . Split responsibilities should be avoided, if possible. A G.C.A. system in which the controller observes both sets of displays, eliminating the need for a tracker, is to be preferred. . . ."

AS IT WILL BE

Such a system has, in fact, been under development for the last two or three years by a telecommunications unit of the Ministry of Transport and Civil Aviation working at Blackbushe Airport on a major modification of the precision radar. The new equipment, designed to present the azimuth and elevation data with the maximum clarity and precision possible, and to function with a high level of serviceability, will be installed at London Airport within a few weeks.

The new approach aid will no longer be known as G.C.A., which embraces both surveillance and precision radar. The surveillance function will be carried out by a main Cossor ACR6 plan-position indicating radar in the control tower, and the talk-down controller will also be stationed in the control tower adjacent to the approach surveillance radar director, instead of in the G.C.A. truck. One of the primary objects of the new precision approach radar (P.A.R.), as it is now to be called, designed by the M.T.C.A. unit, is to provide a remote display which can be operated by one man only, thus simplifying the " servo-chain " by removing one link, the elevation tracker. The display shows true on-course lines and accurate deviations, making the controller's task of interpreting the radar picture a much more straightforward affair than on the old equipment. Fig. 4 shows the upper part of the display console, with two " Azel " displays (Azel—azimuth plus elevation); that on the right covers a range of 10 nautical miles from the touch-down point and that on the left gives an enlarged picture covering a three nautical mile range. In fact, both displays can be adjusted to cover 10, 6 or 3 nautical miles.

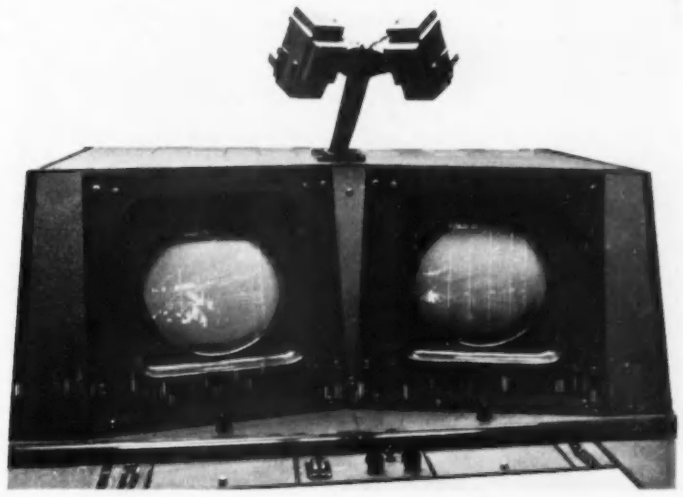

Fig. 4 The upper part of the new display console for London Airport. On the right is a 10 nautical mile display, on the left a 3 nautical mile display. Elevation data are shown on the upper part of the screen, azimuth data below.

The line diagrams in Figs. 5 and 6 show more

clearly the type of display. Fig. 5 shows electronically generated information, and Fig. 6 shows the fixed " mapping " information, which is not generated electronically but is thrown on to the radar screen by the slide projector seen at the top of Fig. 4. Elevation data are displayed on the upper part of the oscilloscope, and azimuth data below; the sweeps are " clipped " to prevent the azimuth and elevation pictures from overlapping. Since the aerials scan alternately, so do their displays appear alternately, azimuth data being blacked out when elevation data are on the screen. The range markers on both presentations are aligned and thus the controller's eye movements are automatically channelled from one picture to the other. In addition, the orientation of the aerials is indicated on the long-range display by brightening the intermediate half-mile range markers (omitted from Fig. 5), and on the short-range display by a solid sector of brightness, over an angular range corresponding to the antenna beam width. This enables the controller to " servo " the aerials to keep them in train with the target; the azimuth aerial being elevated by the short push-pull lever seen on the console control panel in Fig. 4 and the elevator aerial being orientated in azimuth by rudder-type pedals.

Another objective of the M.T.C.A. equipment is a high degree of standby equipment. Thus, there are two display consoles in the control tower, and two independent channels in which every item is duplicated other than the precision azimuth and elevation aerials. The latter, together with the G.C.A. truck in which they are installed, will be the only remnants of the original G.C.A. equipment. The interior of the truck has been completely refitted with redesigned transmitters, receivers, and radar circuitry, and the information generated and received by this equipment will be communicated directly to the equipment room in the control tower through ordinary G.P.O. telephone lines. Although now a standard television technique, the use of Post Office lines for communicating radar signals is an innovation for line transmission of signals of widely varying frequencies.

An external view of the P.A.R. truck is shown in Fig. 7. It differs from the present G.C.A. truck that can be seen at London Airport only in the absence of the search-radar aerial, this equipment having been eliminated. This modification in itself has resulted in more reliable performance in windy conditions. Hitherto, it has not been possible to operate the G.C.A. system in winds exceeding 30 m.p.h. As a result of the reduced wind resistance, the P.A.R. truck can now be used in winds up to 50 m.p.h.

The interior of the re-fitted truck is shown in Fig. 8. In the background is seen the transmitter racks for both channels, comprising two transmitters, two receivers, two radar modulators and two transmitter power supplies. To the left of the transmitter rack is the equipment rack housing the equipment for both channels—the master pulse generator, and the video and trigger signal circuits, which are balanced to earth for sending over the G.P.O. lines. In the left foreground are two power supply racks, one for each channel. The compartments on the right house the azimuth and elevator aerials and the scanning drive gear. The latter is the original drive gear, with the addition of cam-operated microswitches on the shaft to provide an " Azel " switching sequence for relay to the terminal equipment in the control tower. Servoing of the aerials is, however, now electrically actuated and remotely controlled from the console, whereas originally it was carried out directly through a mechanical linkage. Other modifications to the aerial assemblies comprise angle-data take offs and servo take offs which generate direct-current voltages proportional respectively to the scanning angles and servo positions of the aerials for relaying to the control tower.

At London Airport, it is intended ultimately that P.A.R. trucks shall be used at any one of

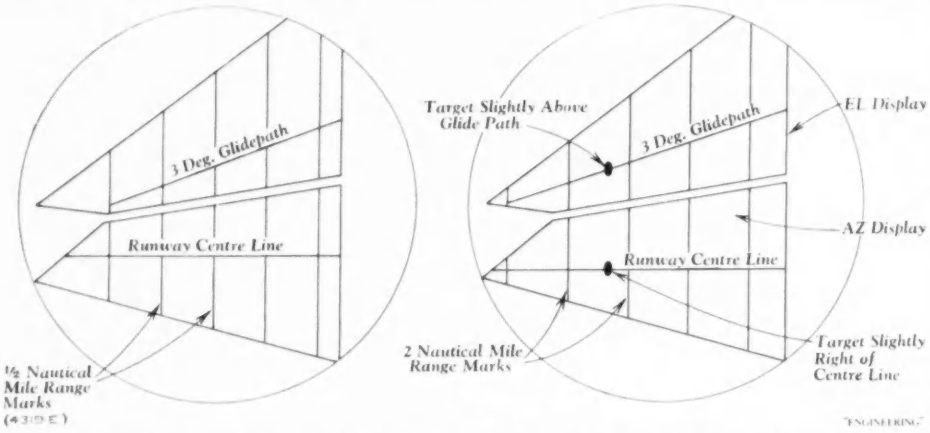

Fig. 5 The electronically generated information shown on the " Azel " displays—glide path, runway centre line, range markers relative to touch-down point, and the moving target. The alignment of the range markers channels the controller's eye from AZ (azimuth) to EL (elevation).

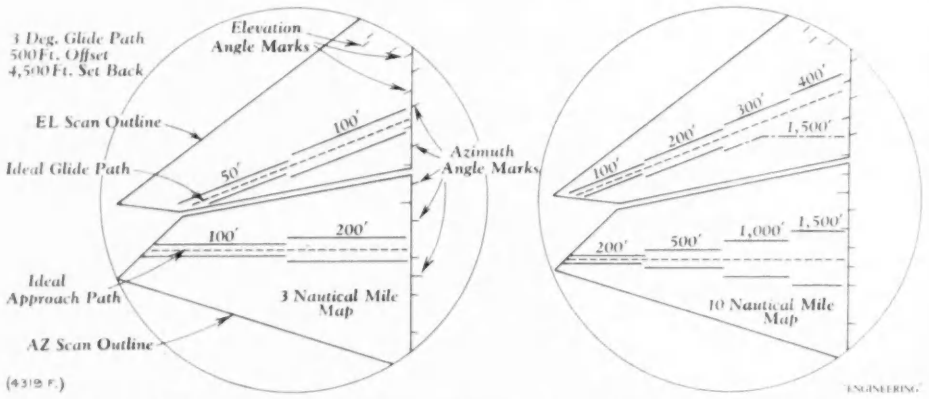

Fig. 6 The fixed " mapping " information—the elevation and azimuth scan outlines, and the deviation indications—are projected on to the screens by the projectors at the top of the display console (Fig. 4).

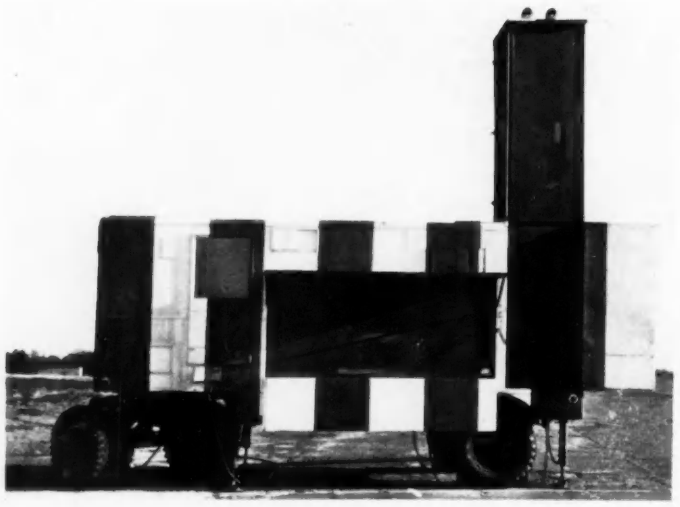

Fig. 7 (left) The new truck is identical externally with the G.C.A. truck, except that the G.C.A. search-radar aerial has been eliminated. The horizontal bay in the centre is the azimuth aerial; the vertical bay on the right, the elevation aerial.

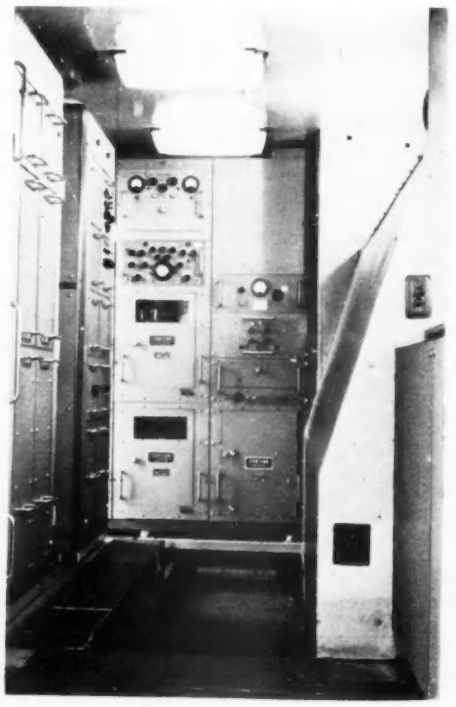

Fig. 8 (right) The refitted truck. In the background is the twin-channel transmitter rack, and to the left of this is the equipment rack and, in the left foreground, the power supply racks. On the right are the elevation and azimuth aerial bays.

eight runway sites. In the equipment room at London Airport, therefore, there will be a site selector unit enabling the desired site, and possibly a standby site in preparation for an expected change in wind direction, to be preselected. The two channels in the control tower will normally be connected to the twin channels on one site, but if desired, one of the two terminal-equipment racks in the control tower equipment room can be connected to a second runway site. This might arise as a result of changing meteorological conditions, or it may be found possible with the new equipment to bring into use two parallel runways during peak periods to relieve bottlenecks. It will then be possible to set up the controls for a changeover on one channel on a master monitoring panel in the equipment room while still operating on the originally-selected site on the other channel.

The terminal-equipment racks in the control tower contain the equipment for generating all the waveforms required for the displays—the trigger generator, range-mark generators, equalisers for the video and trigger channels to counteract the line attenuation and an amplifier to restore the video signal to its original strength, and the scanning angle voltage generator. There will be one twin-channel power supply rack, serving both terminal equipment racks, and two single-channel power racks supplying the display consoles in Approach Control. The master control monitoring panel for the terminal and display equipment, from which the airfield elements are remotely controlled, also provides test facilities for the system.

In addition to providing better data presentation, and generous standby facilities, and circuits designed for reliability, the M.T.C.A. design has aimed at giving maximum accessibility and testing facilities for all components. This has been achieved by some interesting detail design innovations. The equipment racks, for example, are arranged as two-bay units on sliding trays and, from a conventional viewpoint, the units are placed on their " sides " with chassis vertical; thus valves are arranged to face horizontally inwards and their associated circuit components on the back of the unit face outwards. Thus, both valves and circuitry are readily accessible by sliding the unit forward, and this can be done without switching off the power supply and interrupting the operation of the system. The whole unit can readily be removed from the rack if desired. Another feature is the use of hinged perforated component boards of standard form, on one side of which are mounted the components on lugs which project through to the other side of the board, offering test points for checking voltages or waveforms.

By the end of this year, London Airport's new P.A.R. facilities will be in full use, and similar installations will be subsequently made available at the Ministry's other airports.

Letters to the Editor

TWO WORLDS

SIR, We found your leading article of March 29, under the above title, particularly interesting. As a result of thinking along parallel lines for some time, we have concluded that the problem of industrial relations can most usefully be treated as a special case of the more general problem of public relations, with which the advertising practitioner is to-day increasingly concerned.

The crying need is for confidence, based on effectively-conveyed information between management, on the one hand, and not only customers (with whom advertising has in the past been mainly concerned) but also with both shareholders and workers, on the other. The technique and tools available for the effective handling of such propaganda are essentially those of the advertising practitioner. In the case of management/worker relationships, they comprise, as you have noted, films and other suitable media. These media may include such as works magazines, and other printed matter together, probably, with Press advertising—all designed and styled to build up loyalty to the firm, not only as an employer, however good, but as a functional entity in the prosperity of the community. As we see it, the vital thing is that there should be effective overall planning to use every possible means to break down the bosses-versus-men complex and establish the common interest of workers in all grades, from top management down.

It was, therefore, of special interest to learn that similar conclusions had to some extent been arrived at and merited the powerful support indicated by your editorial article.

Yours truly,
BERTRAM WARD,
Partner.

The Technical Advertising Service,
Aldwych House,
London, W.C.2.
April 9, 1957.

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AN ENGINEER'S CARD INDEX

SIR, The letters by Mr. R. Silvester (ENGINEERING, January 11, page 38) and by Mr. J. E. Holmstrom (ENGINEERING, January 25, page 101) deal with a subject of immediate and growing interest to all engineers.

The problem of keeping up-to-date with current literature and, particularly, of filing and indexing data, is one which is exercising the minds of most technicians in greater or lesser degree. There is little real guidance on these difficulties, and most people have to find individual solutions, having widely varying efficiencies. As pointed out by Mr. Holmstrom, the crux of the problem is to provide adequate cross-indexing. The ordinary methods for doing this are cumbersome and inefficient, since the difficulties increase in geometrical progression as the number of different headings for a given subject increases arithmetically.

One solution which has been found most effective for multiple cross-indexing is to use cards having perforations around the edges. Each hole is assigned a significance, and when this significance applies to the subject recorded on the card, the appropriate hole is punched out to the edge of the card with a ticket punch. When the cards are stacked together, and a knitting needle is passed through the holes having the required significance, all the cards which are punched in that hole fall out of the pack.

This system is used extensively in this office for recording particulars of damage to ships, and over 20,000 cases are recorded by this means. It is possible not only to find immediately all the damage suffered by a given ship, but also to extract all the damages of a particular kind suffered by any given group or type of ship over any given period. This particular problem calls, of course, for an enormous degree of cross-indexing, and a considerably simpler system could be devised for recording technical data, articles from periodicals, Press reports, and such-like matters.

The system is not novel, and has been used extensively where extensive cross-indexing is required. It is ideal for recording particulars of personnel, such as multiple qualifications, age, sex, nationality, etc., etc.

Yours faithfully,
G. M. BOYD.

Lloyd's Register of Shipping,
71 Fenchurch-street,
London, E.C.3.
April 11, 1957.

EARLIEST ROLLER BEARING

SIR, May I say in regard to Dr. C. St. C. Davison's letter, published on page 326 of your issue of March 15, that my reference to " *c.*500 B.C." was intended to apply to the Early Iron Age? The period of man's development to which the name " Age " is given may vary in terms of chronology from place to place. The Danish Early Iron Age, I find, was of later commencement, possibly Fourth Century B.C. I am pleased to note that Mr. Ole Klindt-Jensen assigns the Dejbjerg wagon to the First Century B.C. Its age in relation to the battering ram bearing of Diades is immaterial from my point of view, since its importance in bearing history lies in the fact that it was a radial bearing allowing relative rotational motion between the axle and wheel. The Diades bearing—which has its place in bearing history—was in an entirely different category, as it permitted only the motion of translation.

The second paragraph of my original letter (ENGINEERING, March 8, page 292) defined a bearing as an intermediary having the duty, among others, of reducing friction and wear. Thus, there is really minor divergence only between the excavator and Mr. Klindt-Jensen. The excavator considered that the cylindrical members served to reduce wear, and Mr. Klindt-Jensen expresses the further opinion that they rotated with the wheel.

There is, however, some small discrepancy in the paragraph quoted by Dr. Davison from Mr. Ole Klindt-Jensen's book, possibly due to English translation. The term " axle bearing " implies the axle portion. If, in fact, the sticks were housed in grooves in the axle they could not have rotated with the wheel. Further, the illustration in my letter (page 292) shows them in the hub. Whether the wheel rotated on the sticks, these revolving on their own axes in grooves in the axle, or whether the wheel rotated, through the medium of the sticks, around the axle, is for the present purposes immaterial. The sticks show the provision of an intermediary between opposed surfaces to facilitate rotary motion. Garnett's invention, nearly 2,000 years later, is in direct descent, notwithstanding the several rolling bearings of purely thrust type that came in between. In the captions to the illustrations on page 292, the Danish wagons are referred to as " carts," but the usual meaning of " cart " in this context is a two-wheeled vehicle.

Yours faithfully,
J. T. EMMERTON.
(In charge of Patents Department,
British Timken Limited, Birmingham.)
134 Tile Cross-road,
Birmingham, 33.
March 19, 1957.

Editor's Note: Unfortunately, the sketch of da Vinci's rolling bearing which accompanied Mr. Emmerton's original letter (Fig. 3 on page 292), was published inverted.

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TEMPERATURES IN BRAKE DRUMS

SIR, May I reply to Mr. B. B. Hundy's interesting letter, published on page 388 of your issue of March 29, about my article on " Transient Temperatures in Racing-Car Brake Drums " (ENGINEERING, March 8, page 304)?

His first query concerns the effect of the circumferential gaps between the brake linings on the heat input to each point on the drum surface. Although, as he indicates, these inputs are really intermittent, their frequency in the problem concerned was felt to be sufficiently high to warrant the assumption of an equivalent continuous input. This continuous, though declining, input is based on the rate of dissipation of kinetic energy and on the total effective drum area: it thus represents, for any point on the drum, and any particular speed during braking, the averaged value, over one cycle, of the actual intermittent input at that speed. The assumption accordingly results in a faired line, such as D in Fig. 3 of my article, instead of a more

correct " saw-edged " one of precisely similar mean trend.

The conductive cooling described by Mr. Hundy for a zero input period will cause the internal surface temperature to fall from a peak to an adjoining trough on this saw-edged curve. Considering as an example, however, the conditions of my Figs. 3 and 6, and assuming wheels of a diameter of 28 in. and linings each subtending 70 deg., the intermittent input at, say, 1·28 sec. after brake application has a zero input period of only 0·010 sec. The very shortness of this interval suggests a relatively small associated temperature fall, but confirmation is also provided by the very similar conductive cooling process occurring during the first 0·010 sec. after a brake release at $t = 1·280$ sec. during the equivalent continuous input case of my Fig. 6. The scale of this diagram is too small for accurate measurement but the original large-scale drawing shows the internal surface temperature, represented by the upper broken line, to fall through only 18 deg. F., namely, from 415 deg. F. at $t = 1·280$, to 397 deg. F. at $t = 1·290$. Similar calculations for $t = 2·56$, 5·13, and 7·68 give zero input periods of 0·012, 0·017, and 0·034 sec., respectively, and the corresponding values of temperature fall are approximately 7, 10 and 12 deg. F. These suggest that for the problem concerned the simplifying assumptions are justified.

On Mr. Hundy's second point, it must be accepted, of course, that no theoretical analysis can allow for local hot-spots due to random irregularities in the drum surface. With a fabric lining, however, such effects must clearly be of a completely different order from those with a cast-iron shoe. Even for the latter, the discrepancy between theoretical and experimental results, quoted by Mr. Hundy, may not be due entirely to local hot-spots but to the serious under-estimation of maximum temperature which can result from the application of the semi-infinite slab theory to a wheel rim of finite thickness.

It should also be mentioned that the main analysis does not, as stated, necessarily require complete contact between lining and drum. The assumption is that the equivalent continuous input is uniform over the internal drum surface —rather a different matter. For example, given a reasonably uniform transverse distribution of contact regions on the lining, and neglecting local high-spots on the drum, each point on the drum surface undergoes a similar total amount of rubbing and the assumed requirement is satisfied even though only a part of the lining is effective.

Mr. Hundy's comment concerning hair-line cracks is of very great interest, though a little more detail would be welcome concerning the mechanism whereby the thermal pattern in question results in tension at the internal surface on cooling.

Yours faithfully,

F. K. BANNISTER,

Professor of Thermodynamics.

The University of Birmingham,
Edgbaston,
Birmingham, 15.
April 9, 1957.

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The Royal Society of Health has announced the titles of two of its 1957 essay contests. The first is the " John S. Owens," which will be on " The House and Its Heating System." The essay is to deal with the provision of space heating, hot water and cooking for a family of two adults and two children in a house of 1,000 to 1,200 sq. ft. area. The second essay is the " John Edward Worth " and will be entitled " Modern Methods of Space Heating, Central Hot Water and Refuse Disposal in Relation to Central Re-development." Full details of conditions of entry for both these essay competitions can be obtained from the secretary of the Society at 90 Buckingham Palace-road, London, S.W.1.

Weekly Survey

Cover Picture: *The secret of all good boiler construction is accuracy. The illustration shows the furnaces and combustion chambers of a two-furnace Scotch boiler being " set up " prior to fitting into the front end plate (seen on the right). Great care must be taken with this operation to ensure that the combustion chambers are square and parallel to each other; if not, the subsequent operations of staying, tubing, etc., will be seriously affected. Incorrect alignment can set up severe stresses under working conditions.*

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Investment and the Budget

The Chancellor of the Exchequer has given few crumbs of comfort to those who had hoped for some form of stimulus to investment in the Budget. He is clearly more worried about over-stimulating investment than about putting a brake on it. He expects investment to be at least maintained at its recent levels in the new fiscal year and he also expects spending by the public to go up. Taken in conjunction with his apprehension about the trend of bank advances, it is clear that he considers that if he were to stimulate investment further there would be a dangerous strain placed upon the level of imports. These might rise and so endanger the balance of payments position.

As was expected, the Chancellor has weighed carefully the partially conflicting claims of the short-term balance of payments position and the long-term need to stimulate investment. It must have been a difficult decision for him to arrange the priorities for he must be fully aware that this country dare not face the European Common Market with a brake on its investment policy and he himself has been one of the most consistent advocates of the E.C.M. idea. He has, in the event, come down in favour of the short-term balance of payments position. He is worried that the monetary controls which have been used to carry out the deflationary policy of the last two years have been effective thanks only to full co-operation from the banks and he has appointed a committee under Lord Radcliffe to produce a factual study and recommendations on the working of the credit system. The Chancellor has no intention of relaxing the present credit squeeze for he fears that the savings may not be produced to sustain even the current level of investment and he has taken the precaution of budgetting for a large above-the-line surplus as a means of forced saving.

He has thus decided to give away only £98 million in tax relief. Since he is so preoccupied with the dangers of over-investment and inflationary spending by the public it is not surprising that there have been no significant tax remissions for the middle income groups nor extensions in the investment allowance with the exception of shipping. The cynics might say that he has given a measure of relief especially at the top end of the income scale while he could and that it will be the turn of the rest of the income tax payers nearer the General Election. This could be the strategy but it still leaves industry as a whole, including the engineering industry, with no immediate prospect of a fiscal stimulus to invest in plant and equipment on a larger scale than they have been doing in the immediate past. Not everyone will agree that this is the best policy to avoid a downward swing in the trade cycle in the autumn of this year.

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Tonic for Shipping

The Budget decision to increase the investment allowance on new ship construction to 40 per cent. has filled an urgent, almost desperate, need. It is equivalent to the provision of tax-free funds for fleet replacement, and should check the flow of British shipping to Bermuda and other " flag of convenience " countries. The concession, which presumably will be maintained for a number of years, comes at a time when competition among world shipping interests is growing, with unfavourable results for this country's fleet. Most companies have large replacement programmes in hand, and should benefit considerably from the Chancellor's wise decision.

The industry's rate of investment in the past few years has fluctuated between £50 million and £80 million annually, a level far too low to ensure minimum replacements. The shipping industry has realised that a considerable increase is urgently needed and has at present some £700 million worth of orders on British yards alone for delivery during the next eight years. There is room for a considerable increase in this amount, where tankers predominate. New passenger liners are required to meet competition from the airlines, and large dry-cargo tonnage suitable for the carrying of iron ore and other raw materials is in very short supply. There is certainly little excuse for not planning the modernisation of Britain's merchant fleet, 80 per cent. of which was built before 1937, so that it is able to compete with modern ships under foreign flags.

The main obstacle to rapid modernisation is the shortage of capacity in British yards. Although it is highly unlikely that Mr. Peter Thorneycroft's decision would be reversed, even by a Labour Chancellor, shipping companies will want to move quickly to take advantage of the new allowance. Can British yards rise to the occasion or must British owners order extensively from foreign yards? Plain Words in our issue of March 29 pointed to the absurdly low level of capital investment in the shipyards since the war, and the woefully inadequate modernisation plans now in hand. There was a case for investment allowance relief in that direction also, though the prospects of the industry should now appear bright enough even to the most pessimistic of companies and to investors to warrant the injection of the considerable funds that are required to modernise the yards and reduce the time taken to build ships.

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American Cycle Tariffs

Hearings started last week in the United States on the application by the American cycle manufacturers to the Tariff Commission for greater protection against imports from Europe.

Higher duties were last imposed in 1955, the rates being raised from 7½ to 11¼ per cent. on lightweight bicycles and from 15 to 22½ per cent. on medium and heavyweight bicycles. These rates, however, have failed to check imports which have risen from 963,667 in 1954 to 1,174,214 in 1956.

The United Kingdom cycle manufacturers were the first to realise the great potential export market in the United States, and the success of their efforts is reflected in the rise of exports to the United States from just over 14,000 (over 90 per cent. of total imports) in 1949 to over 538,000 in 1955. The United States manufacturers have described foreign companies as enjoying " an unbeatable competitive advantage" and as deriving their cost advantage from " lower wages and inferior conditions."

The continued rise in total imports is no consolation to British manufacturers whose share in 1956 amounted to no more than 23 per cent. or 266,142 machines. The earlier British success was largely founded on the sale of lightweight machines, which to some extent created their own special market, not directly competitive with the types produced by American manufacturers. The bicycle in America is largely used by juveniles and treated with careless abandon. American domestic manufacturers have always catered for this rough usage by

producing heavyweight balloon-tyred types. Over the past year there has been a steady reversion of taste away from lightweight towards medium-weight bicycles. German manufacturers have been quick to realise this, and their share of total imports rose to 53·5 per cent. in 1956. At the same time, it must be pointed out that United States domestic production rose from 1,554,233 in 1954 (the year before the tariff increase) to 1,761,702 in 1956. In spite of the American complaints, therefore, it can hardly be said that the United States makers are likely to be put out of business; the German manufacturers are happy, and the real sufferer, in spite of " unbeatable " competitive advantages, is the British industry. The American market has been described as very sensitive to price. The fact remains, however, that in this instance the British price is not at fault though there does not appear to have been realised here that American tastes have changed.

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More State Control in Italy ?

The appointment recently of the first Minister of State Participation may represent a change of attitude towards state control of industry in Italy. The new Minister takes over a number of industries and institutions that have previously been the concern of other ministries. They include the Cassa per il Mezzogiorno (the re-development fund for the South), and various semi-autonomous institutions in charge of the Italian social services. Another group consists of the state-owned banks, including Banco d'Italia, Banco di Napoli, Banco di Sicilia, Istituto Mobiliare Italiano and other credit issuing institutions. A third group includes the various corporations running particular groups of state enterprises which have up to now been grouped under IRI (Istituto Ricon-strictione Industriale). Among these are ENI (oil and natural gas), FINSIDER (iron and steel), STET (telephones), RAI (broadcasting and TV network), FINELETTRICA (electrical engineering), FINMECCANICA (mechanical engineering), FINMARE (shipping lines) and a host of smaller concerns throughout the whole range of manufacturing industry.

Among the plants that now come under direct state control for the first time are Cornigliano and Dalmine the foremost steel works in the country. The Italian Government is a minority shareholder in a number of private enterprise concerns including Montecatini. State participation touches all parts of the economy. The administration of those sections which came under IRI has never been noteworthy for its efficiency. Indeed, the fact that the long arm of the State reached so far into basic industries has been cited as one of the main reasons for the backwardness of Italian industry. It is not surprising, therefore, that Italian business men are full of misgivings at this new political move. Italy, they feel, has more than enough nationalisation already.

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Americans Abroad

Last year United States citizens and private business invested 2,746 million dols in foreign countries This is the largest figure since 1928, and represents the highest volume of capital investment abroad since the end of the war. This is greater than the total of the United States Government's foreign loans and grants. The analysis of the outflow of private funds in 1956, in the current issue of the Federal Reserve Bulletin, shows that over half the total—1,500 million dols—went to foreign branches and subsidiaries of United States companies, and that the bulk of it was invested in industrialised and developing countries. This country and Germany in Europe, Canada and Brazil in America and the major oil producers were some of the favourite hunting grounds of the United States investor.

This, clearly, is United States industry's answer to the dollar shortage and proof of its growing determination to secure a hold in expanding markets. Parallel with this investment there was a large increase in short-term and medium-term credits to foreign customers, by no less than 700 million dols. The Bulletin notes a " significant " growth of bankers' acceptances, which is said to have resulted from the demand for export finance. A substantial increase in American competition in world markets must therefore be expected, but there is also every likelihood that American private investment will greatly stimulate industrial growth in the western hemisphere.

One of the latest and largest of American companies to enter the British industrial field is the Cummins Engine Company. In their annual report to shareholders for 1956 the directors describe the formation of the Cummins Engine Company, Limited, at Shotts, Scotland, where a works of some 150,000 sq. ft. has been leased. Production will begin this year and the plant is expected to be in full operation within two years. Total investment will amount to some 4 million dols during 1957 and 1958, and the plant will eventually employ 800 people. Cummins' expansion has been rapid since the war. Last year net sales totalled nearly 106 million dols, representing a 45 per cent. increase in unit sales. They now account for 55 per cent. of automotive Diesel engine sales in the United States. The development of turbo-charged engines has gone ahead and a range of 8 cylinder V-type engines is expected to go into production during the fourth quarter of this year. The company's announcement that the output of the British subsidiary will be sold " primarily within the countries of the sterling bloc . . . when sales are now impeded because of exchange difficulties " is a clear expression of the main purpose of United States investment abroad.

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African Shareholders

The Rhodesian Selection Trust Group of Companies has taken a further step in the advancement of Africans in the copper mining industry by announcing a scheme to encourage employees, both African and European, to become shareholders in Rhodesian Selection Trust and Roan Antelope Copper Mines. While full details of the scheme have not yet been announced, it has been stated that facilities will be provided to enable employees to subscribe up to a fixed proportion of their wages each month towards the purchase of shares in these companies. Employees' contributions will be matched up to 50 per cent. by the employing companies and the total contribution will be used to purchase the shares in the open market. Membership of the scheme is limited to employees earning a basic rate of pay above a stipulated minimum, and until this minimum is announced it is impossible to say how many employees will be affected. The three main companies in the group employ a total of about 3,300 Europeans and 19,000 Africans.

The progress already made by the group towards the advancement of Africans has not been achieved without opposition, most of which has come from the Africans themselves, many of whom are inclined to see in any scheme to advance the more skilled and more intelligent men an attempt to weaken the African front to the Europeans. Much of the unrest on the Copperbelt between July and September last year, which culminated in the declaration of a state of emergency by the Northern Rhodesian Government and the appointment of a Commission of Inquiry, was due to opposition by the African Mineworkers' Union to the companies' recognition of the African Staff Association. Though this is an attitude not unknown in more developed countries, it is undoubtedly the main obstacle to African advancement since the European mineworkers, after some initial opposition, have largely accepted the principle. In spite of the unrest last year there can be little doubt that the Rhodesian Selection Trust Group are right in developing the policy of African advancement, both from the point of view of their own particular interests and from the wider aspect of helping to resolve the racial problems of Southern Africa. The development of their latest plan, which is believed to be the first scheme in southern Africa to encourage share ownership by employees, will be followed with interest.

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Application of Electronic Computers

As electronic computers become more generally available there will be a growing need to inform industry in general of the types of problem which such computers are able to solve and the advantages which can be derived from their use. In the April issue of *Works Management* Dr. D. G. Prinz and Mr. C. M. Berners-Lee of Ferranti, Limited, give a number of examples of the application of computers to linear programming or optimal planning problems. Such problems may be broadly defined as those which require the solution of a multiplicity of linear equations involving a large number of unknowns subject to the restriction that a certain linear function of the variables, e.g., their total cost, must be at a minimum.

A classical example of this kind of problem which frequently occurs in the oil and chemical industries is the least-cost mix problem, where it is desired to produce at the lowest cost a composition which may comprise in varying proportions a number of ingredients, whose individual costs are known, subject to certain restrictions. In the engineering industry a similar problem may arise in repetitive machine shop production. There are a number of feasible production cycles each of which produces articles in different proportions and involves varying amounts of idle time. The sales pattern is given and the problem is to determine how long the plant should operate on each cycle in order to meet the sales demand with minimum idle time. Certain problems of structural design may also be expressed in this way.

If the number of variables is small, problems of this nature may be solved manually, but the great advantage of the electronic computer is its speed of operation. For example, it is no use attempting to solve a least-cost mix problem manually, if the solution is going to take such a long time that prices will have changed before it is reached. Provided the number of equations and of variables is within the limits of the machine, an electronic computer can generally solve such problems within half an hour and substantial savings may be achieved for an outlay of £50 or £100 on machine computations. The Ferranti-Pegasus Computer limits the size of the problem to either 30 relations in 95 variables or 46 relations in 63 variables, though if the problem has certain special features these limits may be considerably extended.

There is clearly great scope for further study of industrial problems with a view to finding their simplest mathematical form which will permit programming for electronic computers and also for publicising to industry the types of problems which can be solved in this way.

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Radio Industry Concentration

The decision of Electric and Musical Industries and Thorn Electrical Industries to merge their radio and television receiver interests follows closely upon the decision of Ferranti to turn over their domestic receiver manufacture to E. K. Cole, who had previously absorbed Dynatron. The concentration now taking place in the industry is an indication that large production and marketing units are essential to successful

competition in this field. Production will be mainly concentrated in the Thorn factories at Enfield and Spennymoor and the resulting rationalisation is expected to yield manufacturing economies which should enable the group to compete more effectively and to meet "the challenge of European economic integration."

The severe recession experienced by the industry in receiver sales last year, when output fell by over one-fifth, is probably the immediate cause of the movement towards concentration. Thorn's great strength in the television market where sales are still rising, will give the group resources required to prepare for the severe competition that lies ahead, when the initial demand for television receivers has been satisfied over the whole country. Together the two companies have over 15 per cent. of the domestic television sales and 10 per cent. of radio sales. This should give them a substantial cost advantage over several of their smaller competitors.

E.M.I. will be freer to concentrate on the production and marketing of gramophone records and on the further development of industrial electronic equipment where they have expanded considerably in recent years, particularly in computers and machine tool control. Both labour and factory space will be released for this purpose. Thorn will retain the lamp, lighting fittings, cookers and aircraft equipment divisions of the Ferguson organisation.

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The Electrical Woman

Feminine interest in electrical matters is demonstrated by the attendance at the annual luncheon of the Electrical Association for Women—around 600 were present. As Lady Rhys-Williams said during her speech, electricity in the home has been the greatest revolution in the social field. Gone were many of the back-breaking tasks that were regarded as commonplace, but most women now had to know how to use electrical and electro-mechanical apparatus as a result of their emancipation by gadgets. Women, too, were more and more taking their place in industry, and entering the professional fields, although, as Miss Mary Field said in her speech, the opportunity was still not fully recognised. Miss Field also appealed for standardisation of plugs and sockets throughout the country to avoid the tiresome necessity of changing all the equipment when moving from one district to another.

Mr. David Renton, Parliamentary Secretary to the Minister of Power, outlined to those present the Government's plans for capital expenditure on power. It was an interesting point that whereas not so many years ago power stations were being built for railway and industrial consumers, now even the complete electric traction scheme of British Railways would demand no more than a fraction of the domestic load throughout the country. Though the capital cost of nuclear power stations was greater at present than that of conventional plant, it was estimated that the running costs would be less, and therefore the cost per unit generated could be reduced. These stations would have to run as base-load plant to be fully economical. Although Miss Field had said that opportunities for women in engineering were not large, Mr. Renton pointed out that the Government Technical Education facilities were not yet fully used and scarcely at all by women. In future, nearly everybody would have to study science—politicians included.

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Full Employment Ahead

On the last day of the recent conference of the British Institute of Management at Southport Sir Harry Pilkington, chairman of Pilkington Brothers and last year's president of the Federation of British Industries, spoke of the future with confidence and expectation: "we are going to have full employment for the rest of this century, or at least it is within our power." Far from being short of work, he could see "no prospect of satisfying all the legitimate demands upon us during our lifetime."

Sir Harry's assumption was a continued rise in living standards the world over. Britain had to keep up with this, to enable this generation and the next to live at least as well as the people of other industrial states. Yet a tremendous call on investment resources was called for, without which we could not maintain our production effort. We should have "to choose which things to do first." The demands for investment on the part of the basic industries were immense. He mentioned coal, nuclear power, railways, roads, steel, tankers and technical education. For a decade now three of these have been neglected to the point of folly. Now we must catch up, and either restrain consumption or step up productivity. The latter, Sir Harry said, was almost entirely the responsibility of management, including trade union management and foremen and supervisors also.

The fact that very much higher investment and higher exports are possible without necessarily reducing consumption is borne out by the increases in productivity open to most firms in engineering and other manufacturing industries. More effective management, improved methods, fewer and better co-ordinated products, better information on markets are some of the measures open to all at little cost. Their adoption could yield undreamed of increases in productivity. The leaders in each industry have demonstrated the truth of this over and over again. Yet too many remain inefficient almost by choice, restrict output through fear, limit competition and therefore enterprise to ensure what they call "stability." It is time British management and labour realised the truth and significance of Sir Harry Pilkington's remarks.

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Boiler Makers' Challenge

The annual statements of several makers of boilers and boiler-house plant show that 1956 has been a year of outstanding results, and that the future holds considerable promise in circumstances of rapid technical change. The demand from the Central Electricity Authority for thermal capacity of the conventional type is showing definite signs of slowing down. Nuclear plant programmes are taking shape and where coal or oil-fired boilers are required they are changed almost beyond recognition by the adoption of very large units operating at super-critical temperatures and pressures. The position was well summarised by Mr. J. B. Woodeson, chairman of Clarke, Chapman and Company, Limited, in his speech to shareholders last week: "Since the war a substantial proportion of our business in both marine and land departments has consisted of contracts which are not only longer in term, and larger in dimension, but more pioneer in character than the company has previously attempted." In an earlier statement, Mr. G. R. T. Taylor, chairman of International Combustion (Holdings), Limited, had pointed out "the fluctuations which must invariably result from the very substantial increase in the size of individual units and the reduced number of individual orders."

Thus the industry's future success will be dependent on effective planning and estimating more than ever before, to assess contractual liabilities in fields where experience is slight and theoretical conceptions subject to continued changes. Clarke Chapman have, like most of the large builders, invested on a large scale in research facilities. Extensive investigation has taken place into welding techniques, particularly into the application of the ultrasonic examination of welds. As their chairman points out, the entry into the nuclear field has necessitated "additional and entirely new lines of research and development."

Profits in 1956 have in most cases broken all previous records, thus providing essential resources for additional capacity and research. One of the leading makers of boilerhouse plant, Senior Economisers, Limited, recorded an increase of 23 per cent. in trading profits, to £243,747. The company's rapid expansion in recent years in the industrial and marine field shows that the industry's prospects are excellent, particularly in export markets. Provided it can rise to the technical demands that are being made upon it, therefore, there is little doubt that the British boiler-plant industry has many prosperous years ahead.

NEW B.M.C. SMALL CAR

Compact Four-Seater with Good Power-to-Weight Ratio

The new Wolseley 1500 saloon announced last week will take many minds back to the Wolseley Hornets of the early thirties, for it continues the same formula: a small, compact four-seater saloon, with enough power to give it an effortless high cruising speed, and faster-than-average acceleration. The new model has, however, broken with the besetting fault of British small car design—excessive engine revolutions. The B.M.C. B-type four-cylinder engine of 1,489 c.c. in a car with a dry weight of 1,974 lb. permits use of a relatively high axle ratio of 3·7 : 1. Road speed at 1,000 r.p.m. in top gear is 18·5 m.p.h., so at a cruising speed of 70 m.p.h. the engine is doing less than 3,800 r.p.m. Brisk acceleration up to 75 m.p.h. is available in the third speed of the four-speed gearbox.

The car has an entirely new body-chassis structure, with a torsion-bar front suspension which is a scaled up version of that used so successfully on the Morris Minor. Rear suspension is semi-elliptic, and like the Minor, the car has its piston-type dampers clamped to the rear axle, an arrangement which increases unsprung weight and would appear to make them vulnerable to casual damage from rocks and stones, but does not appear to have caused any great criticism on the smaller car. The engine has a single semi-downdraught SU carburetter, and a 7·2 : 1 compression, appreciably lower than on other recent B.M.C. models. This produces 50 b.h.p. gross at 4,200 r.p.m. (43 b.h.p. installed) and a maximum torque of 74 lb.-ft. at 3,000 r.p.m.

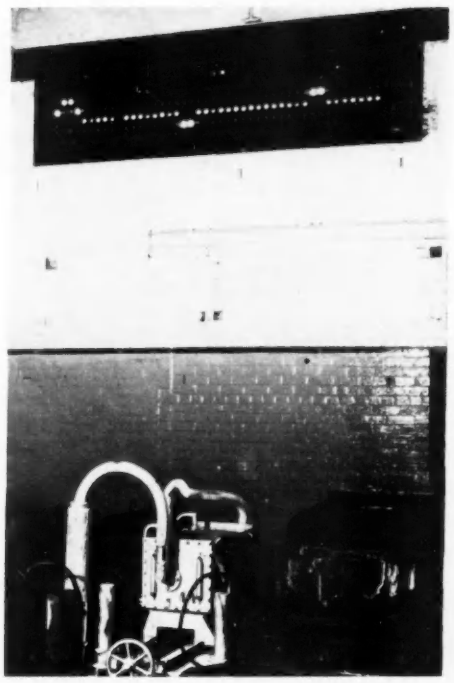
There is comfortable space for two on separately adjustable front seats, and space for two in the rear, with more comfort than on true baby cars, but still with definite restrictions on head and knee room. Interior finish is in usual Wolseley custom style, with liberal use of walnut veneer, and leather.

It is hardly to be expected that the B.M.C. would contemplate the high tooling outlay necessary for this new body-chassis unit solely for a Wolseley model, and it will presumably find eventual applications on other models. In this connection it is interesting to note that by changing a single pressing, the front ends of the wings, the radiator grille opening, and the whole frontal aspect of the car can be altered.

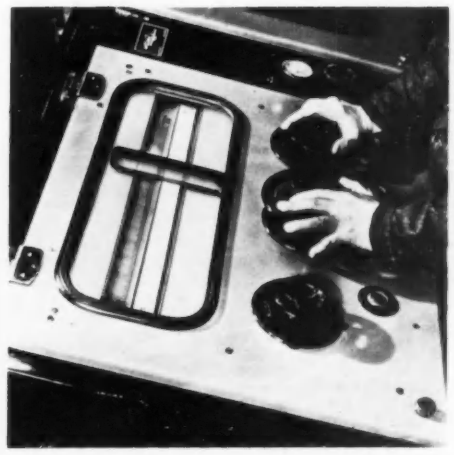
CONTINUOUS γ-RAY GAUGING OF HOT STEEL STRIP

INDICATING AND TELEPRINTING THICKNESS METER

For the past year a new adaptation of the " gamma-ray " type of thickness gauge has been in continuous use at the rolling mills of the Steel, Peech and Tozer works, Rotherham, repeatedly and automatically gauging the thickness of hot steel strip at one-second intervals. The new instrument has been developed by the Baldwin Instrument Company, Limited, Dartford, Kent, to meet the precise needs of the steel strip industry for measuring the thickness of fast moving hot strip. At the Steel, Peech and Tozer works, the strip, up to 9 in wide, moves at speeds up to 2,400 ft. per minute. The Baldwin thickness gauge is arranged to measure the thickness between limits of 0·03 in. and 0·25 in. The regular use of the instrument has enabled manual gauging to be reduced to a minimum, and it has been found to be of considerable assistance in setting up the mill after a change in thickness.



Mounted above the source holder (in lower foreground) and detector units of the Baldwin hot-strip thickness gauge is the display board which presents a picture of the thickness variations of the strip, clearly visible to all the mill personnel.



Part of the operator's control desk, showing the alloy selector (which adjusts the calibration of the machine), the " set thickness " control, and the tolerance control. On the right of this control panel, not visible, is the teleprinter unit.

The equipment comprises the measuring head, made up of the source unit and the detector unit; the electronic cabinet; the display board; and the operator's display board, adjacent to which is a teleprinter installation. Measurement is by non-contact means, using a strontium 90 source of " bremsstrahlung " radiation, and a radiation detector placed one either side of the hot strip. The intensity of radiation falling on the detector varies with strip thickness, causing the detector output to vary. These variations, after passing through the electronic equipment, are displayed in two ways, on a lamp display board and as a permanent teleprinter record.

MEASURING HEAD

The source unit which houses the radioactive source is also fitted with self-adjusting equipment which is brought into operation only when the instrument switches itself to " standardise." This occurs as the trailing edge of the strip passes through the measuring gap; the sudden increase in radiation falling on the detector is arranged to change the instrument from the " measuring " to the " standardising " condition. In this condition, a signal from the electronic unit causes a pneumatic cylinder to place a circular disc of metal of standard thickness over the radioactive source. The instrument then measures this standard and compares the signal voltage with a preset voltage; if the two voltages do not agree, a servo-motor is set in motion to readjust the preset comparison voltage. There are, in fact, six standard metal discs in the source unit and the appropriate one is preselected by means of a control on the operator's desk. The complete unit is housed in a rugged water-cooled jacket.

The radiation-sensitive element in the detector unit is a thallium-activated sodium iodide crystal which scintillates when radiation falls upon it. The visible light from the crystal is picked up by two photomultipliers, one of which acts as the measuring device for the instrument, the other as a relay which causes the changeover from the measuring to the standardising condition, and vice versa.

The output from the measuring photomultiplier feeds into an integrating circuit which averages the current over the time cycle of approximately one second. The output from the integrator is then fed to the amplifier in the electronic unit.

When the trailing edge of the strip passes through the measuring head, there is a considerable increase in radiation reaching the crystal and a corresponding increase in visible light. The second photomultiplier detects this change and causes the instrument to switch to the standardising condition, whereupon one of the six standard discs in the source unit is moved into position, thus reducing the radiation reaching the crystal. When the leading edge of the next strip arrives in the measuring head, there is a sudden drop in radiation at the detector; the relay photomultiplier reacts to this and causes the instrument to be restored to the measuring condition.

The source and detector units are mounted on either side of the strip, which passes between them in the vertical plane through a water-cooled slotted guide. The units are easily separated for maintenance and removal of the guide by turning a handwheel, and may be moved in a vertical direction by adjustment of a control wheel on the operator's console. This allows the radioactive beam to pass through various points across the width of the strip and also accommodates the variation of strip width. This movement is carried out by a specially-designed mechanism actuated by a power cylinder with accurate position control.

DISPLAY AND RECORDING

The amplifier output, in the electronics cabinet, is fed to a discriminator which classifies each signal into one of five levels, depending upon the magnitude of the signal. This in turn, depends upon the average thickness of strip passing through the measuring head during the appropriate second. The five levels are arranged to represent: out-of-tolerance positive, intermediate positive, nominal thickness, intermediate negative, out-of-tolerance negative. The five levels of thickness are represented by five banks of a uniselector which is stepping round at one-second intervals over 50 contacts each.

Once every second, an impulse is applied to one of the five uniselector banks, depending on the voltage of the signal entering the discriminator. The impulse will be fed to one of the uniselector contacts and the appropriate relay will be operated.

A pictorial presentation of the longitudinal profile of the strip is indicated on the display board seen at the top of the left-hand illustration. This comprises 48 vertical rows of five coloured lamps. The middle green lamps indicate that the strip thickness is well inside specified limits; the adjacent amber rows signify that it is just inside, and the outer red rows, that it is outside limits. The tolerance limit can be set on the instrument to suit the rolling specification which is usually in the region of 0·002 in. to 0·010 in.

The lamps are operated by the relays connected to the contacts of the uniselector. Thus, for each second during which strip is passing through the measuring head, an impulse from the detector causes one of five lamps to light, depending on the deviation of the average thickness of the strip from the preset thickness. As the strip moves past the gauge, the lamps trace out the thickness profile. When the whole length of the strip has passed the gauge, the longitudinal thickness profile of the whole strip is displayed on the board, which remains alight until the leading edge of the next strip enters the gauge. The display board is sited so that everyone concerned can see it and take the necessary remedial action, whether this be adjustments to the mill rolls or altering the temperature distribution in the pre-heating furnace.

A Creed teleprinter provides a permanent record of the longitudinal profile of each successive strip in digital form. It has been adapted to print the following signs, representing thickness error: $\pm + 0 - =$. This form of recording, in comparison with graphical chart recording against a time base, has a considerable advantage of indicating clearly, in a compact space, the trend of a large number of strips. In general, the operator does not act on individual strips but observes a trend before taking action.

The control desk, shown in the right-hand illustration, contains all the controls which are necessary for the day-to-day operation of the equipment: a " set thickness " control, the required nominal thickness being set on this dial and the display board then showing deviations from this setting; a range selector, which preselects the standard metal disc for use in the standardising condition; an alloy selector switch, which calibrates the instrument to suit the particular alloy being measured; and the tolerance control, which enables the maximum and minimum tolerance limits to be adjusted.

The installation has been provided with means to test various portions of the equipment without the use of other main units. For example, if a fault is suspected in the control desk, a simple adjustment at the rear of the instrument enables the control desk to be disconnected entirely and replaced by a built-in test facility.

OIL ABSENT IN 11 KV CIRCUIT BREAKER

AIR-BREAK SWITCHGEAR USING RESIN INSULATION

For some time there has been a growing interest in this country in the use of air-break switchgear for voltages greater than 3·3 kV. This has led to the study and development of an arc-chute whose magnetic circuit is energised directly by the arc itself instead of by one or more coils in series with it. At the same time, with "oilless" circuit-breakers for such voltages in prospect, research has been undertaken to develop cast-resin insulants suitable both mechanically and electrically for the primary insulation of the fixed portion of the panels. These materials would be of a standard at least equal to that of the conventional insulants, such as compound and oil.

The culmination of this work has been the production by A. Reyrolle Company, Limited, Hebburn, County Durham, of the 500 MVA 11 kV resin insulated air-break panel illustrated in Fig. 1. This has recently been successfully tested for short-circuit performance to the requirements of the Association of Switchgear Testing Authorities. The unit is 7 ft. 6 in. high, 2 ft. 9 in. wide and 7 ft. 1 in. deep, with a minimum wall-to-wall requirement of 15 ft. The normal current ratings are 800 and 2,000 amperes, and the busbars, which are of the continuation type, may have a rating of 2,400 amperes. The insulation of the fixed portion is epoxy resin, and the joints are insulated with a filled polyester resin in such a way that if necessary they may be broken down and remade on site.

CURRENT TRANSFORMER ORIFICE

The current transformer orifice insulator primary is cast as one unit, as shown in Fig. 2, and is provided with a small platform on which the cores and secondaries are mounted. These are positioned by a brass tube which is fitted concentrically with the primary conductor and is provided with a fixed clearance to the primary insulation so that discharge at working voltages is obviated. The cast-resin voltage transformer plugs into a set of orifice insulators above the current transformer chamber, and is horizontally withdrawable on its own trolley. Access is obtained from the back, and, in the withdrawn position, the voltage transformer can be rotated about a vertical axis to permit the fuses, which are housed within its plugs, to be changed.

The front of the cubicle shown in Fig. 1 is 6 ft. 7 in. high, but this may be increased when instruments and relays have to be mounted on the panel. The compartment with the control handle houses a large terminal board, fuses, and the racking gear for the secondary circuit isolating contacts. The latter can be connected with the circuit-breaker in the isolated position.

INSULATOR DESIGN

The circuit-breaker insulators, including the driving links, are of cast-resin and advantage has been taken of the fact that the casting process facilitates the manufacture of a cranked bushing to provide an integral earthing feature. The main circuit-breaker contacts are mounted on plant-pot insulators into which are fitted cranked insulated connectors, as shown in Fig. 3, with cluster-type isolating contacts fitted to both ends. The cranked bushings may be rotated through 180 deg., thus permitting the circuit-breaker to be plugged into any of three positions: normal circuit, feeder earth, or busbar earth. The three positions are suitably interlocked and label indication is brought forward to the front of the panel.

As already mentioned, the arc-chutes of the circuit-breaker do not require coils to energise an external iron circuit in order to produce the flux necessary to drive the arc into the chute. Instead, sandwich-type arc-chute plates are used, in which an iron sucker-loop is moulded between plates of refractory material, as shown in Fig. 4. Consequently, not only is the additional equipment of an external magnetic circuit unnecessary, but the time required for the arc to switch in the coils is avoided, since it actually now uses its own magnetic field.

ARC-CHUTE FEATURES

In addition to this new iron feature the arc-chute is so constructed that the arc moves initially in a very restricted tunnel. This means that the arc movement in the lower part of the chute is under complete control and consequently it cannot move down the chute without re-establishing itself upon the runners. This ensures consistent performance.

The arc-chute plates are slotted, the slots being inclined in opposite directions throughout. As the arc rises in the chute the slots force the arc column into a zig-zag path of ever increasing length until their tops are reached. Further bowing of the arc then takes place between adjacent arc-chute plates beyond the ends of the slots, as shown in Fig. 5. A series of plates prevent the arc from moving out of the top of the arc-chute and cool and deionise the gases.

It might be thought that with the iron as an integral part of the chute the weight of the chute would proportionately increase. That this is

Fig. 1 (above) Reyrolle's new 500 MVA 11 kV air-break circuit-breaker with the arc-chutes raised and the side sheet removed to show contacts.

Fig. 2 (left) Current transformer orifice insulator and primary stem.

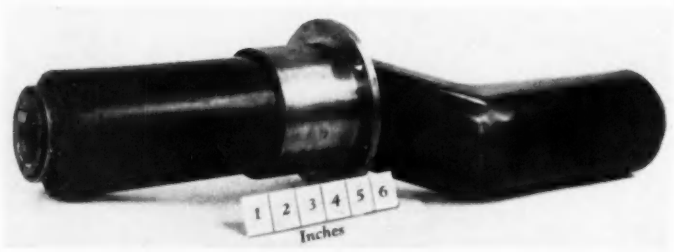


Fig. 3 (left) Cranked circuit-breaker bushing.

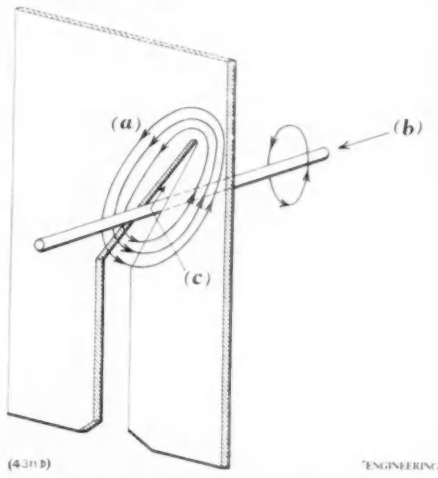


Fig. 4 The effect of an iron sucker plate on the arc column.
(a) Lines of magnetic force in the iron.
(b) Direction of current flow.
(c) Direction of force on the arc column

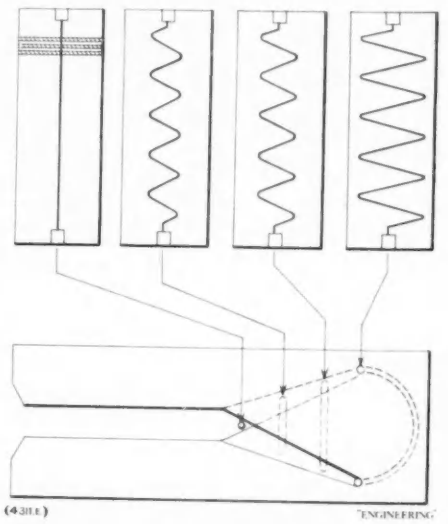


Fig. 5 Diagram illustrating how the arc column is lengthened in the slots.

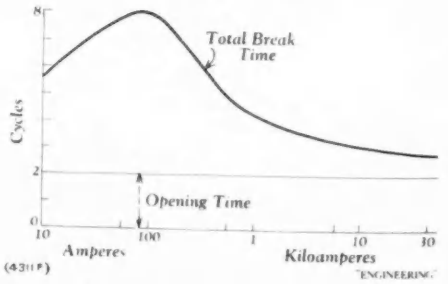


Fig. 6 Typical arc duration/breaking current curve.

not the case is due first to the relatively small amount of iron used compared with the external iron circuits, and second to the density and quantity of the refractory material which in any event has to be used. The arc-chutes do require special handling facilities, however, but this problem has been overcome by using the normal racking-gear of the circuit-breaker to tilt them for maintenance inspection and for replacing the plates if that should be necessary.

CLOSING MECHANISMS

The circuit-breaker is closed by a solenoid and opened by springs, both the opening and closing operations being controlled at the end of the stroke by oil dashpots. The speed of break, which is of considerable importance since slowness may result in unnecessary arcing at the bottom of the chute, is about 15 ft. per second measured at the arcing tip at the time of contact separation. The opening springs also drive two pistons which deliver air to three nozzles situated below the fixed main contacts. The air puffs so produced move low-current arcs into the chute more rapidly than they would move under their own self-induced driving forces. A graph of the way arcing time varies with current is reproduced in Fig. 6. When interrupting the higher short-circuit currents the arcing times are less than 1 cycle and for currents from 2½ per cent. to 100 per cent. of the short-circuit rating arc extinction occurs within 5 cycles of initiation of tripping.

A PHOTOGRAPHIC FACTOR

In conclusion something may be said of the part played by photography in the development of air-break circuit-breakers. In the early research, when basic principles were being established, it was necessary to obtain as complete an understanding as possible of what went on in an arc-chute both during a clearance and during a failure shot. This was by no means always possible from the oscillographic records of current and voltage, and consequently arc-chutes with transparent side sheets were built and high speed photography was used to record vital information. At later stages of the development the same technique enabled even incipient troubles to be recognised and put right, with the result that a remarkable consistency of performance has been achieved.

TIME AND SLOW MOTION STUDIES

Penetrating Glaciers to Measure Rate of Travel

Only during this century has it been realised that glaciers were true rivers in that they actually move forward. A certain amount of local evidence of the fact, as given by the delivery of bodies of unfortunates who had fallen into crevasses many years before, was not known to the scientific world in general. The first to make attempts to measure the rate of flow were some of the early climbers of the Alps. They found to their surprise that not only did the ice actually flow down the ravine, but also the centre portions moved more quickly than the sides. A true example of viscous flow. One of the most recent attempts to measure the relative rates of different sections of ice movement was that made by the Cambridge Austerdalsbreen expedition which last year went to the Odinsbre ice fall in Norway. Details of the method used by them have now been released.

The problem was to sink a rod or marker from the surface of the glacier to the bed rock below. This was done by enclosing a heater in an aluminium-alloy tube and allowing it to penetrate the ice. The heating element was constructed from a 2·5 kW unit made by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, and cast in aluminium by the A.P.V. Company, Limited. Tests were carried out with three elements identical in form but with dissipations of 1·5, 2·0 and 2·5 kW. All proved quite satisfactory, and the largest one was chosen. The heater had to be designed so that it could be extracted from the pipe after bed rock had been reached, and this was done by drawing it up on the end of its cable. The element consisted of a closely wound conical coil of nickel-chromium-iron alloy tube about ⅜ in. diameter, containing a helical coil of nickel-chrome resistance wire packed in magnesite. The cone of the aluminium casting containing the element was lapped to fit accurately inside the conical cap of the pipe. The stainless steel tube linking the conical cap to the aluminium pipe served to reduce the conduction of heat up the pipe. In contact with the upper end of the heating casting, there was fitted a bi-metal thermostat adjusted to cut off the supply within 5 to 10 seconds of the cap loosing contact with the ice, thereby preventing burning-out of the coil.

The pipe was introduced normal to the surface of the ice, that is at an angle of 65 deg. to the horizontal, and it slowly melted its way in, eventually reaching a depth of 129 ft. After this it made no further penetration, so it was assumed to have reached bed rock. The speed of penetration during a test was about 1·2 in. per minute. Throughout the operation the hole around the pipe remained full of water to the surface, no cracks or crevices of detectable size were observed, and whenever the pipe was sinking a steady stream of bubbles rose to the surface. Additional lengths of pipe were added as required. The outside diameter of the pipe was 5 in., and in laboratory tests a hole 5⅛ in. in diameter was drilled by it. By the inclination of the pipe after a period of time, the rate of travel of the various layers of ice will be determined.

To measure the angle, an inclinometer was developed by the Building Research Station, which can either be slid inside a pipe, or when equipped with magnetic wheels can be used to follow the surface of a steel structure. When suspended from its reading cable inside a pipe the position of its internal pendulum is recorded by means of a Wheatstone bridge circuit, and the true inclination of the pipe is obtained, but not the azimuth. Any inclination can be recorded to about ± 0·1 deg. The pipe will be left in place in the ice for a long period and its inclination measured at intervals.

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INCREASING USE OF MAN-MADE FIBRES

It has been estimated that industrial textile materials constitute some 30 per cent. of all the textiles made in the United States, and, although no definite statistics are available for Great Britain, it appears reasonably probable that the proportion is much the same in this country.

Some conception of the nature and multifarious uses of industrial textiles could be gained from a visit to the second Industrial Textiles Trade Fair organised by Trade Fairs and Promotions, Limited, with the National Trade Press, Limited, Drury House, Russell-street, London, W.C.2, and held in the Royal Albert Hall, London, S.W.7, from April 1 to 5. This collection of fabrics and fabric products included beltings for all types of machinery, tarpaulins and coverings for the transport operator and for marine use, wrapping and packaging materials, aircraft braking parachutes, fire and other hoses, fishing nets, filter cloths for liquids and gases, brake and clutch linings, ropes, and protective and specialised clothing. Numerous exhibits were based on such well-known fibres as cotton, wool, flax, jute and asbestos, but as, nowadays, many of the major developments in the textile field are concerned with artificial, or man-made fibres, as they are usually called, large numbers of exhibits involved applications of rayon, nylon, Terylene and other manufactured fibres.

On the stand of British Nylon Spinners, Limited, 25 Upper Brook-street, London, W.1, was to be seen a very large, heavy nylon-corded rubber tyre intended for an earth-moving machine. Such tyres, it is said, can absorb repeated shocks and are unharmed even when used on rough roads for long periods. Another application is in nylon ropes, used on account of their high strength/weight ratio and their ability to absorb very heavy shocks. Nylon gill and other nets are finding increasing favour in the fishing industry because they are almost invisible in the water, while upwards of 10 million ft. of nylon lightweight lined fire hose have been bought by British fire brigades, and considerable quantities are being sold overseas.

The numerous applications of Terylene polyester fibre " on land, sea and air," were shown on the Fibres Division stand of Imperial Chemical Industries, Limited, Imperial Chemical House, Millbank, London, S.W.1. Terylene filtration fabrics for hot gases and acids, and conditions where abrasion or bacteria exist, can be used at temperatures in the region of 150 deg. C. The polyester fibre is also used for fire, hydraulic-brake, hot-air and oil-refuelling hoses. The material combines low-stretching qualities with high-strength and rot-resistance properties. It is also employed for ropes and cordage, canvas, sail-cloth and nets.

In addition to their well-known asbestos products, including special cloth manufactured for use on the bowls of laundry calenders and ironing machines, Turner Brothers Asbestos Company, Limited, Rochdale, Lancashire, exhibited a representative selection of their Duraglas pure glass textiles, including yarns, tapes, rovings (untwisted strands of glass), woven cloths and mats. The physical and chemical properies of Duraglas are such that fabrics produced from it are incombustible, will withstand high temperatures of the order of, 600 deg. C., are resistant to most acids and alkalis and are impervious to the attacks of fungoid growth, vermin and insects. This most versatile material is used for chemical filtration and for heat, sound and electrical insulation. One large-scale application is as a protection for steel pipes, where its strength and resistance to corrosion are valuable properties.

Perhaps the most important single use of Duraglas, however, is as a reinforcement for plastics, enabling the simplest and the most complicated shapes to be moulded with equal facility. The hulls of boats, motor-car and caravan bodies, motor-cycle side cars, translucent corrugated sheeting, radar domes, ducts and pipes and trays and boxes for laboratory use, have been moulded entirely from these reinforced plastics; they possess great strength and high impact resistance coupled with relatively low weight, and if damaged they can be easily repaired.

Examples of a natural textile, namely, presewn hessian wrapping material, in tubular form, together with a variety of commodities of various shapes and sizes packed in the product, were shown on the stand of the " Quick-Wrap " Tubing Company, Limited, Jute Mills, Bow Common-lane, London, E.3. This firm produce these hessian tubes to cover goods in 11 diameters ranging from 6 in. to 36 in., and in rolls approximately 160 yards in length. The tubes replace hand-sewn covers and the benefits claimed are the speeding up of packing processes, the utilisation of unskilled labour, convenience in use, improvement in the appearance of the packages, and ease of handling. All the packer has to do is to select the appropriate size of tube, pull it over the package, tie both ends by means of wire and cut the end still attached to the roll.

Braided rubber cords and rings for all types of shock-absorbing and suspension requirements, and rigid or braided-rubber endless round driving belts, for light high-speed machinery, were to be seen on the stand of Luke Turner and Company, Limited, Deacon-street, Leicester.

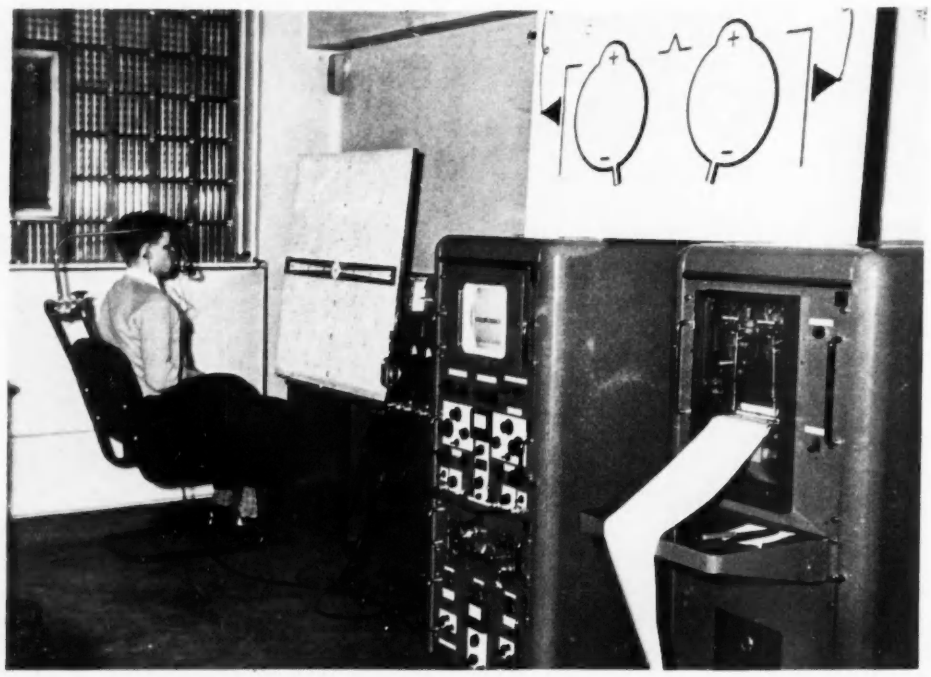

Fig. 1 The diagram, above the cabinets housing the electro-oculography equipment, represents the manner in which the eyes behave as a battery—a phenomenon which can be used for measuring the movement of the eyes.

MEASURING EYE MOVEMENT

A PRACTICAL SYSTEM OF ELECTRO-OCULOGRAPHY

Most of us use our eyes. Some people, notably those operating large control panels, or driving vehicles, use them a great deal. It comes as a surprise therefore to find that only recently has a great deal of attention been paid to the manner in which we see. In particular the way we move our eyes from point to point and the way we scan an area have only recently begun to be investigated with thoroughness.

The difficulty in the past has been to register exactly the direction in which the eye is looking. It is not possible to ask a person to say the manner in which his eye moved when he changed his gaze from point A to point B. We have an inbuilt mechanism that prevents us registering any impressions as our eyes move from object to object. One technique that has been tried is that of reflecting a beam of light off of the cornea. The procedure tends to introduce spurious results due to the effect of the spot of light, and is also limited in its accuracy and in the range of eye movement that can be recorded. A more recent development is an electrical method—electro-oculography—that registers eye position by detecting the small changes in skin potential that occur when the eye position changes.

This technique has recently been developed by the Psychological Research Laboratory of E.M.I. Electronics, Limited, Feltham, Middlesex. Their equipment measures up to 30 deg. of eye movement with sufficient accuracy to make the results extremely useful. A practical and complete system of eye movement measuring apparatus has been developed and the first has been supplied to the naval motion study unit of the Admiralty Research Laboratory. A typical application of the apparatus is to determine whether people overshoot or undershoot when they move their eyes to a new object. Overshoot is the case where when the eyes move rapidly to a new object they swing slightly past it and then come back to rest on the object. Undershoot is the case where the eyes slow down before they reach the object and then move on to it. Tests already show that both types of response are met. It should be possible to discover which types of person show predominately one mode of response. In this respect it would be of interest to see the way skilled racing drivers behaved. If for example it was discovered that they overshot each time, it would suggest that this manner of using the eyes is best where rapidity of response is a premium. On the other hand, it might be found that the other sort of response is less fatiguing. Such data would enable the industrial psychologist to specify the most efficient manner in which the eyes should be used for a particular application. The equipment would also be of interest to advertisers since it could show the parts of an advertisement that attract the eye first and the manner that an individual scans any particular display. There are many other applications.

Electro-oculography is possible because the eye acts as a small battery. The cornea carries a positive voltage and the retina a negative one. A diagram appears in Fig. 1 to illustrate the effect. Electrodes are placed either side of the eyes in a horizontal plane and above and below one eye in the vertical plane. When the eyes look straight forward no voltage appears at the electrodes. If the gaze moves to either side a voltage appears that is proportional to the angular displacement. In the horizontal plane the eye voltages are in series. For 30 deg. eye movement each eye provides about 300 microvolt at the skin. Some losses are experienced in the series combination and about 500 microvolt appear at the horizontal electrodes for the 30 deg. deflection. The eyes being in parallel, electrically, in the vertical plane, only the voltage due to one eye is obtained at the vertical electrodes.

Difficulty is experienced with spurious skin voltages. To overcome the effect of these, an external voltage is applied in the opposite direction to balance out voltages that remain when the eyes are looking straight ahead. Since the balancing is in two dimensions it is somewhat laborious, and a servo-mechanism has been developed to do the balancing. The actual position of the eyes is displayed by a spot of light on the face of the cathode ray tube. The cathode ray tube display was originated by Dr. N. H. Mackworth of the M.R.C. Applied Psychology Research Unit, Cambridge. In effect the voltage from the vertical electrodes is fed

Fig. 2 The measuring jig shown establishes the exact position for the electrodes on the horizontal and vertical planes of the subject's eyes.

Fig. 3 To diminish unwanted skin voltages, the skin is lightly drilled at the points which receive the electrodes. To ensure that the subject's head is located in the same position for each experiment, a dental positioning-jig having a plastic impression of the subject's front teeth is used.

to the plates which deflect the spot vertically and the voltages from the horizontal electrodes to those which deflect it horizontally. Consequently if the subject being tested is looking at a target card such as is shown in the illustration, it is possible to superimpose a copy of the target on to the face of the tube. The position of the light spot will reveal at a glance the direction in which the eyes are looking and also the path taken when the attention is switched from one part of the target to the other.

For analytical purposes a two-channel pen recorder is used in which the pens record the vertical and horizontal movements separately. The pens provide valuable information concerning type of eye movement—absence or presence of smoothness—speed, and degree of overshoot or undershoot. To operate the oscilloscope and the pen recorder, the small eye voltages are amplified by a high gain direct-current amplifier. The amplifier is of the chopper type and has an input impedance of about 1 megohm. The skin output impedance is about 5 kilohm.

The spurious skin voltages that arise are further reduced by careful attention to the electrode system employed. The location for the electrodes is determined by use of the jig shown in Fig. 2. The exact position having been located, the skin is drilled at the point which will receive the electrodes. The drill only removes a small portion of the outer skin and draws, no blood. The electrodes which have been previously soaked for 30 minutes in a 1 per cent. saline solution, are then attached. The electrodes themselves are of silver chloride electro-deposited on pure silver, and are mounted in rubber suction caps which cling to the skin. Prior to attachment, the caps are liberally greased with saline jelly.

With the subject gazing straight ahead the spot is brought to the centre of the cathode ray tube display by appropriate backing-off voltages. The servomechanism that does this is actuated by a push button and accomplishes its task in a second or two. In order to locate the subject's head in the same position every time, there is a dental positioning-jig which can be seen in Fig. 3. Various types of test card may be used. In the one shown in Fig. 5 each dot represents five degrees of eye movement.

Different people give different amounts of voltage per degree of eye movement; accuracy can therefore be expressed only in statistical and not in absolute terms. With an average subject, tested in one minute spells, one can now be sure of recording horizontal eye movements to better than $\pm$ 1·5 deg., and vertical eye movements to $\pm$ 2 deg. for 70 per cent. of the testing time. For shorter spells—for example, 20 to 30 seconds—the accuracy is better than $\pm$ 1 deg. for at least a similar percentage of the testing time. With selected subjects in one minute spells, an accuracy can be assured of $\pm$ 1·5 deg. for more than 90 per cent. of the time, and better than $\pm$ 1 deg. for at least 70 per cent. of the time.

These figures assume that all results are plotted from an arbitrary zero level. It has been found, however, that the residual zero drifts are usually almost linear, so that by using a pen recorder and interpolating the zero level from the zero points at the beginning and end of the recording spells (whether they be one, two, or more minutes), it is possible to make a reliable analysis of the record to better than $\pm$ 1 deg. of eye movement for an entirely satisfactory percentage of the total recording time.

WATERWORKS DESIGN

Replacing Labour by Automatic Controls

Public water supply pumping systems would seem to be very suitable cases for the application of automatic and semi-automatic control devices. They are, on the whole, simpler than many of the processes in chemical plant which are already fully controlled by automatic means, and they are also processes which operate continuously—for long periods requiring no adjustment at all. The fact that automatic control is being steadily introduced into this long established industry is brought out in a paper by Mr. T. Irvine Hudson, presented to the Institution of Mechanical Engineers on April 5 and entitled "Modern Trends in Water-Works Pumping Machinery." Trends from the past are traced through the slow speed and mainly steam driven plant of the Nineteenth Century to the modern high-speed installations; progress on the design of pumps and the use of high-tension electric motors for submerged operation are also discussed.

The limitations of the alternating-current motor as the driving agent, mainly due to its speed characteristics, are also considered, together with the possibilities of using germanium rectifiers. One of the problems that has been faced is the variation in demand both during the day and during the year. The problem that this brings up is that of stand-by plant and plant for base and peak loads. Steam was the normal prime mover up till the end of the Nineteenth Century, when producer gas and paraffin engines driving reciprocating pumps made their appearance in pumping stations of small size. The centrifugal pump then came into its own, together with the heavy oil engine, and later the electric motor. Now, the majority of pumping stations are equipped with electrically-driven base-load plant with heavy-oil engines used as stand-by.

Another development in the past 20 years is that of the submerged motor operating in a borehole, and the most recent development in this field has been the use of high-tension supplies at 3,300 volts in order to reduce both the mass of copper required and the starting surge on the mains. At present the largest one installed is of 1,000 h.p. but there does not seem to be any major difficulty against increasing this figure considerably, as continuous running periods of 40,000 hours are nowadays considered normal. Apart from complete automatic control of stations, considerable use is being made of remote control whereby one or more small stations can be operated from a main one. The reduction in staff that this makes possible is one of its great advantages in view of to-day's shortage of labour, particularly for the kind of work that involves continuous day and night running.

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MOBILE WORKSHOPS

Heavy Equipment for Power Station Maintenance

When power stations are far apart, mobile workshops can often provide better maintenance than can a fixed depot. With this in mind, the British Thomson-Houston Company, Limited, Rugby, Warwickshire, have introduced two mobile units for servicing turbo-alternators. Utilising factory-trained personnel, the unit consists of a 14 ton road vehicle carrying milling machines and surface grinders, heating and hydraulic equipment for removal and replacement of turbine wheels on built-up rotors, cover-band punches, etc.

A specially designed lathe has been built for transport on a low loader to the power station site. This lathe is in sections which can be assembled on the power station floor, the bedplate being levelled by means of jacks. The machine is capable of swinging steam rotors up to the 120 MW L.P. size, and is used for cutting out damaged blades, threading replacement blades, and machining blade roots and cover bands. A machine for static balancing a completed rotor is also provided.

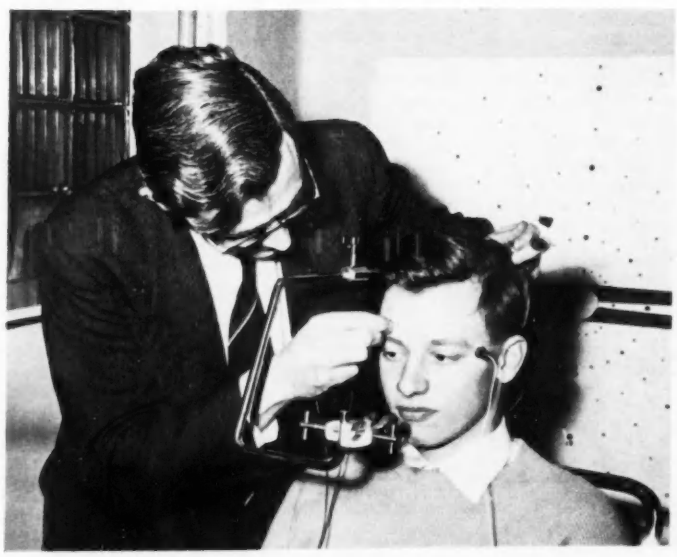


Fig. 4 The electrodes are held in position by rubber suction caps. A saline jelly is smeared within the cups prior to attachment.

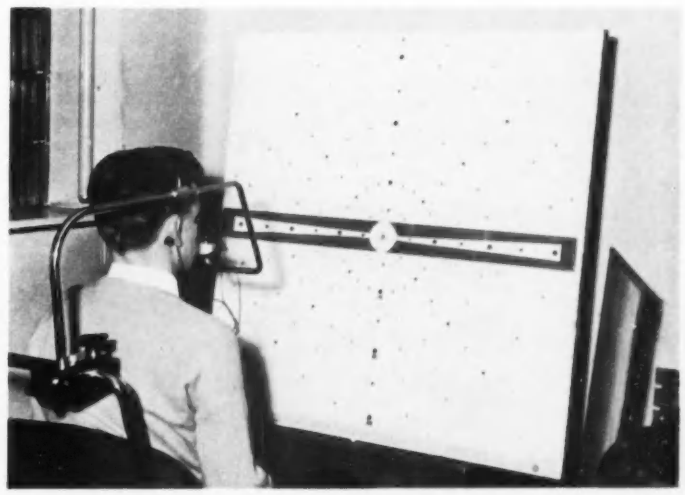


Fig. 5 When the subject is correctly seated before this particular form of target board, each dot represents five degrees of movement. Such a target board is used for fundamental experiments in eyes movement. Different boards are used for experiments on reading, mental arithmetic, etc.

THE SKID-WHEEL

NEW METHOD OF MOVING HEAVY LOADS ON SOFT GROUND

By E. R. Stables, B.SC.(ENG.), A.M.I.C.E., A.M.I.MECH.E., A.F.R.AE.S.*

This article describes a projected method of moving heavy loads on soft ground. It records the origin, theoretical analysis, and development of a skid-wheel aircraft transporter up to the completion of a series of tests on a full-scale experimental model. The device may perhaps be of interest in fields of engineering other than the one in which it arose.

* Assistant Director of Aircraft Equipment Research and Development, Ministry of Supply.

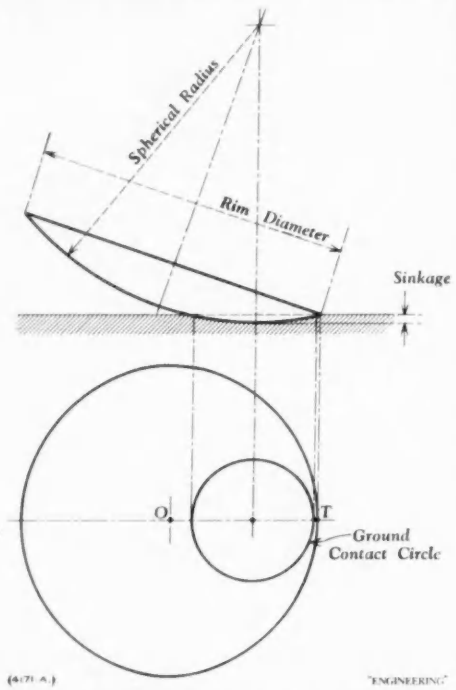


Fig. 1 The skid-wheel consists of a saucer-shaped pan freely rotating about an axis slightly inclined to the vertical, and bearing on the ground near its rim.

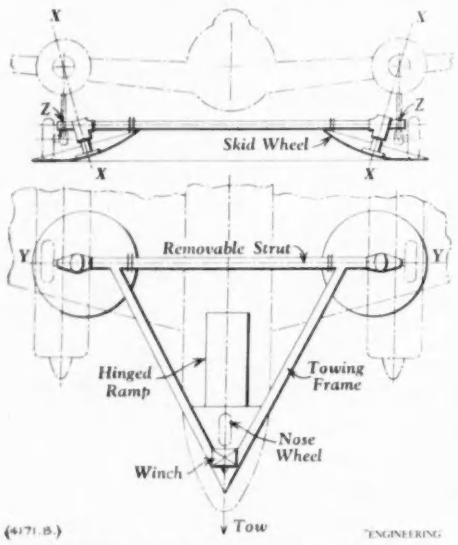


Fig. 2 An aircraft transporter based on skid-wheels; the transporter is towed from the apex of the triangular frame. The nose wheel is supported on a small platform held clear of the ground.

The " skid-wheel " (British Patent No. 759,608) as its name implies, is a cross between the skid and the wheel. Its purpose is to combine as far as possible the load-spreading ability, low height, and general simplicity of the skid with the low tractive resistance of the wheel. The idea arose from the problem of towing aircraft over natural soil; this problem has received considerable attention both in the United Kingdom and abroad, particularly because of the increase of tyre pressures to well over 100 lb. per sq. in. Aircraft tyres carrying loads appropriate to such pressures may sink so far in natural soil that direct towing of the aircraft may become difficult or impossible, requiring excessive tractive effort and subjecting the aircraft structure to unacceptable strains. A variety of aircraft transporters have been designed and made, based on the conventional wheel and axle or on endless tracks, but such transporters for carrying loads of 10 to 20 tons are apt to be unwieldy and costly things, especially when the loads to be carried are concentrated at two or three widely separated points, as with modern aircraft undercarriages. Also, the wheeled transporter must incorporate means for raising the load on to platforms to ensure that chassis and running gear are kept clear of undulations in the ground. This lifting takes time and adds complications to the transporter or its associated equipment.

In 1952 the Royal Aircraft Establishment experimented with towing aircraft on plain skid pans. The essence of this scheme was simplicity, the skid pans consisting of flat steel plates, one for each wheel, their forward ends curved upwards to prevent digging-in. The plates were connected together by a simple triangular frame which was dragged along by the tractor. Mounting the aircraft on such a transporter was quick, needing only a hand winch to draw the aircraft forward on to the plates, the lift being negligible. A transporter was made on these lines and tested, but it was difficult to manoeuvre and the draw-bar pull was high, requiring a large tractor.

THE ROTARY SKID

The attractiveness of the skid-pan scheme from all other points of view, however, was very great, and this prompted the author to consider whether the plain skid might be developed in some way to reduce its tractive resistance. This could, of course, be done theoretically by reducing either its coefficient of sliding friction or its velocity relative to the speed of pull. An appreciable reduction of friction coefficient seemed unlikely, but it appeared that a skid might perhaps be " geared down," as it were, so as to have a low velocity whilst in contact with the ground, and higher velocities when free of the ground. An endless rotating skid appeared to be needed, and a saucer-shaped pan freely rotating about an axis slightly inclined to the vertical and bearing on the ground near its rim seemed to offer the sort of motion required. (Fig. 1.) The load could be applied to the ground either through the centre bearing and thence through the pan or, in the case of an aircraft, by allowing the aircraft wheel to bear directly on to the pan vertically above the centre of the ground contact area and to rotate freely with the rotation of the pan. Incidentally it seemed that such a pan might be used as a drive, and it appeared to offer something of the effect of a large wheel at considerably reduced height.

PRACTICAL CONSIDERATIONS

The mechanical construction of an aircraft transporter on these lines seemed fairly straightforward. (Fig. 2.) Two pans would be needed, one for each main wheel of the aircraft. The nose wheel could be supported on a third pan or, preferably, on a small platform held clear of the ground by the tractor vehicle. The two pans and nose wheel support could be connected together by a rigid triangular frame which would be towed from the apex. Bending stresses in the structure should be low by reason of the directly opposing load and ground reaction at each main wheel. Mounting the aircraft in the pans appeared to be almost as simple as with flat skid plates, for the pans could be permitted to tilt backwards when the aircraft wheels, on being winched forward, came in contact with them. Manoeuvrability seemed likely to be good

Fig. 3 Close-up view of undercarriage wheel mounted on the experimental skid-wheel transporter.

because of the differential action of the two pans. Location of the aircraft relative to the transporter frame did not appear likely to cause difficulty, but tyre scrubbing might, since the aircraft wheel would in effect be continuously rounding a curve of small radius. However, this could perhaps be overcome by a lubricant or if necessary by a static platform supported just clear of the pan.

A model skid wheel transporter having pans about 6 in. diameter was made. A model aircraft was placed upon it, and the required motion seemed to be obtained. The sliding velocities of points on the surface of the pans in the vicinity of the area of contact with the ground were obviously much lower than the speed of tow.

THEORETICAL CONSIDERATIONS

Before proceeding further it seemed desirable to attempt a theoretical assessment (see Appendices) of the performance of the device to obtain, if possible, some idea of the order of the advantage what might be expected from it, in comparison with fixed skid plates or wheeled transporters.

It seemed fairly clear that the area of contact with the ground should be as near as possible to the rim of the pan if the draw-bar pull was to be kept to a minimum, since the nearer this area

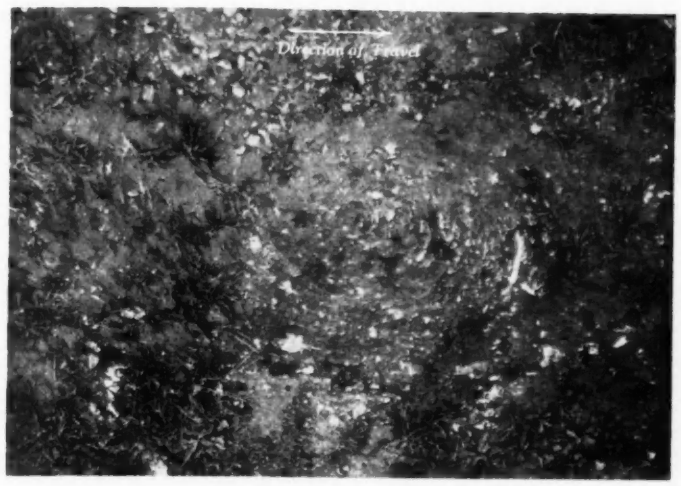


Fig. 4 Skid pattern on soil.

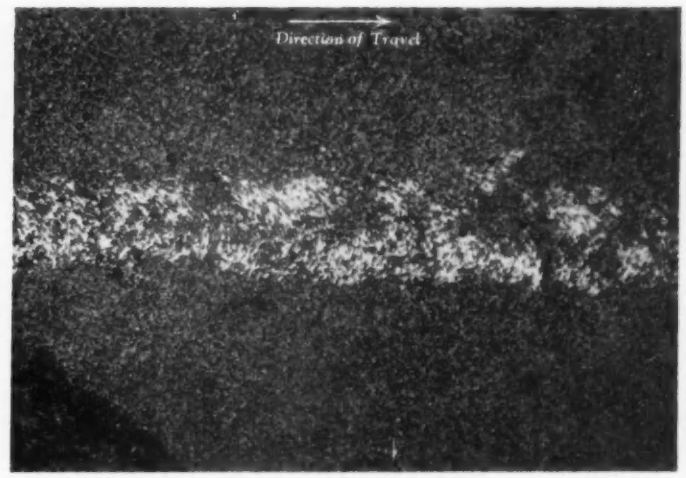


Fig. 5 Skid pattern on tarmac.

came to the centre of the pan, the nearer the arrangement approached that of a fixed skid, until, in the limit, if the ground contact area were symmetrically disposed about the centre, rotation would cease. This also implied that, for a given ground-contact area, the larger the pan the better. A large pan, bearing on a small area near its rim, would approximate to an endless track or a very large diameter wheel, in its action on the soil. Practical considerations would, however, limit the size and proportions of the pan according to the free space available under the aircraft wings and fuselage.

The theoretical estimate of tractive effort required could, it seemed, be based on assuming that the ground contact would probably be confined to the outer half or two-thirds of the radius of the pan, since this gave reasonable scantlings for a transporter for the aircraft concerned and promised a large multiplication, up to 20, of the tyre contact area, with very small sinkage, using a pan of about 6 ft. spherical radius and 6 ft. diameter.

EXPERIMENTAL MODELS

The theoretical estimates indicated a draw-bar pull of about one quarter of that required by a plain skid. This was sufficiently promising to justify making a $\frac{1}{4}$ scale-model skid-wheel transporter, based on the requirements of aircraft weighing up to 20,000 lb. This model was made and tested on prepared beds of soil. The results gave rough confirmation of the theoretical estimates, and a full-scale experimental model was then constructed. It weighed 1 ton and had mild steel pans 5 ft. 6 in. diameter, 6 ft. spherical radius, and $\frac{3}{8}$ in. thick. It was tested during the summer of 1956. Fig. 3 shows a close-up view of one of the skid-wheels, with the aircraft undercarriage mounted on it.

About 30 measured hauls were made, each about 100 ft. to 150 ft. long, using aircraft giving ground loadings of from 4 to 8 tons approximately. Tyre pressures were 120-130 lb. per sq. in. The combination of available sites, aircraft weight, tyre pressure and experimental equipment was not ideal. The top soil at the airfields was shallow and the sub-strata too solid to demonstrate great sinkage of the aircraft wheels by themselves; at a load of 6 tons the ruts made were only about 5 in. deep. However, when loaded to about 8 tons it was considered unwise to tow the aircraft alone in view of the possibility of excessive momentary strains being imparted to the undercarriage. The skid wheels at the same weights made impressions between $\frac{3}{8}$ in. and $\frac{7}{8}$ in. deep approximately, and in view of the low specific loading it was thought that this amount of sinkage would probably be independent of the depth of top soil.

Tractive Effort and Speed.—The tractive effort was supplied by a Scammell vehicle and measured by means of an oil-compression instrument and by an electronically-recorded strain gauge apparatus. The speed of haul was limited to walking pace when recording the pull, but the loaded transporter performed very smoothly at speeds up to 10 m.p.h. Higher speeds were not attempted, but there was nothing to indicate that the limit had been reached. The mean draw-bar pull values varied between 200 lb. and 600 lb. per ton load, the lower values occurring on greasy soil and the higher ones on stony ground. Initial pulls on starting were usually about double the mean pull when moving but they were difficult to measure accurately as they depended to a considerable extent on the control of the engine and clutch of the towing vehicle. A number of runs were made with the pans deliberately locked to simulate plain skids and the pull then needed was from 50 to 400 per cent. greater than with the pans rotating. The average mechanical advantage, compared with pure skidding, seemed to be between 2 and 3 to 1, that is, the skid-wheel could be expected to require half to one-third of the pull needed with a plain skid. These values were obtained with pans which appeared to be a little on the small side for the loads carried, and an improvement could be expected with pans increased in diameter from 5 ft. 6 in. to 6 ft. 6 in. or 7 ft. After the measured pull tests it was demonstrated that a 3-ton Bedford 4 by 4 vehicle, unballasted, could pull an aircraft without difficulty on skid-wheels at about 6 tons weight, but at 8 tons wheel spin occurred on a greasy surface. This performance should improve with larger pans.

Instantaneous Centre Position.—The width of the tracks made in the soil varied from 14 in. with 4 tons load on stony ground, to 23 in. with 8 tons loading on ground with soft top soil. Measurement of the distances towed and the number of revolutions made by the pans gave the positions of the instantaneous centres for each run. They were reasonably near the centres of the tracks, showing that the sliding velocities were probably as low as could be expected with the particular configuration. The instantaneous centre positions were further confirmed by the circular skid patterns made in the soil and on the tarmac, as shown in Figs. 4 and 5 above.

Manoeuvrability.—Manoeuvrability of the transporter was good because of the differential action of the pans. The aircraft could be turned on any radius that the tractor could provide, turntable motion being imparted if required. This appears to be an advantage over orthodox wheeled or tracked transporters which usually require fairly large turning radii. The transporter also appeared to be self-tracking; on greasy soil there was no tendency to slew sideways, as occurred when the pans were locked.

Robustness.—Between the test runs there usually occurred a haul over tarmac or concrete. On one occasion one of the pans ran over a crowbar lying on the concrete. No deformation or noticeable wear of the pans or hardstandings occurred; the transporter was towed with the aircraft over the abrupt edges of hardstandings on to adjacent soil, sometimes several inches lower. The freedom of the pans to tilt backwards appeared to be an advantage when travelling over hard obstacles or undulating ground, as the pans accommodated themselves automatically to the contour of the surface.

Mounting and Dismounting.—This proved to be quick and simple. A small hand-winch mounted at the apex of the towing frame drew the aircraft on to the pans which tilted downwards and backwards as required and returned to a central position when the aircraft wheel was fully in. The nose wheel was simultaneously drawn up a short ramp on to a platform where it was chocked fore and aft. Dismounting was equally simple, using the winch with rope reversed around the transporter frame.

Lubrication of the Tyres.—The first few tests were made with the inside surface of the pans unmachined, with a black forged finish. Excessive tyre-scrubbing occurred, even when the tyres were run in a pool of glycol and water. The pans were then ground smooth and a little castor-base lubricant was smeared on the tyres. This eliminated scrubbing completely. Water was found to be equally effective with the smooth pans.

MAIN DESIGN DETAILS AND RECORDED DATA

A summary of the main design features and the measurements made is given below:

Total load applied to the ground through two skid-wheels	4 to 8 tons (approx.)
Rim diameter of skid-wheels ..	66 in.
Thickness	0·375 in.
Spherical radius	72 in.
Angle of inclination of axles ..	18½ deg.
Width of tracks made in the ground	14 in. (4 tons) to 22 in. (8 tons)
Ground loading (at all imposed loads)	25 lb. per sq. in. (approx.)
Aircraft tyre pressure	120/130 lb. per sq. in.(approx.)
Depth of sinkage	0·4 in. to 0·9 in.
Distance from centre of skid-wheel to centre of contact area	22 in. (mean)
Distance from centre of skid-wheel to instantaneous centre	25½ in. (mean)
Draw-bar pull (skid-wheels rotating)	200-600 lb. per ton
Draw-bar pull (skid-wheels locked)	300-2,000 lb. per ton

APPENDIX I

Theoretical Analysis

The theoretical analysis made an interesting exercise. If an attempt were made to take into account all the forces involved, including shear, compression, suction and sliding, the analysis seemed likely to be very difficult. Sliding friction was probably the predominant factor if sinkage was small, especially in the towing application, and it was therefore decided to ignore the other forces and to try to estimate the draw-bar pull

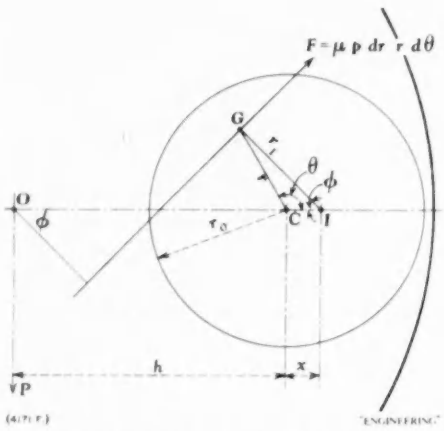


Fig. 6 Notation for theoretical analysis:
O is the centre of the skid-wheel.
C is the centre of the contact circle.
I is the instantaneous centre.

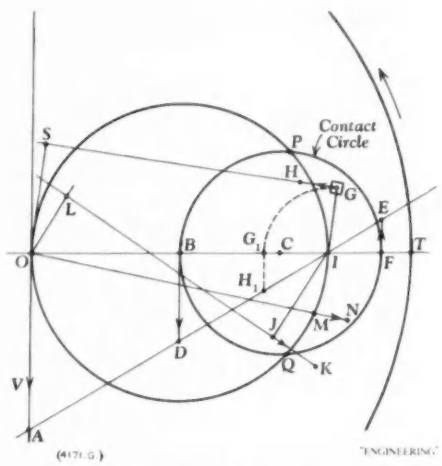


Fig. 7 Construction for elementary analysis.

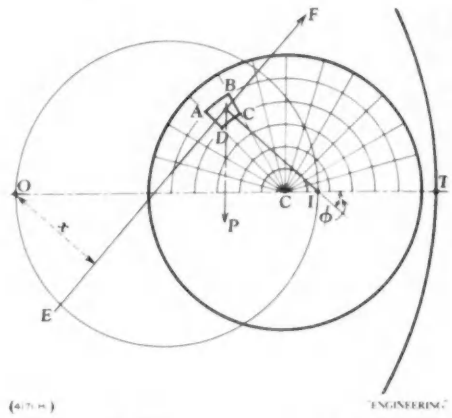


Fig. 8 Construction for approximate estimation of position of instantaneous centre and tractive effort.

in terms of the load and the coefficient of sliding friction between the skid-wheel and the ground. To do this it seemed advisable first to determine the velocity of any point on the surface of the pan, relative to the ground. Velocities could obviously be found without difficulty if the position of the instantaneous centre were known. If the pan made point contact and rotated without slipping, the point of contact would be the instantaneous centre, as in the case of a wheel. If rotation ceased and the pan were dragged as a plain skid, the instantaneous centre would be on a line perpendicular to the direction of motion and at an infinite distance away. But the position of the instantaneous centre when the pan rotated while making contact over an appreciable area was not obvious; if the area were small and circular, the instantaneous centre would almost certainly be near the centre of the area; if large, it would be somewhere between the centre and infinity. It was therefore important to determine where the instantaneous centre occurred.

BASIC ANALYSIS*

In Fig. 6, neglecting the curvature and inclination of the pan, if p is the normal ground reaction per unit area, μ the coefficient of friction, I the position of the instantaneous centre, P the tractive force at O, the centre of the skid-wheel, r_0 the radius of the ground contact circle, then, taking moments about O—since the skid-wheel is free to rotate:—

$$0 = \int_0^{2\pi} \int_0^{r_0} \mu\, p\, dr\, r\, d\theta \{(h + x)\cos\phi - r_1\} \quad (1)$$

r_1 and ϕ can be expressed in terms of r, x and θ, from the triangle G C I.

Resolving forces in the direction of motion:

$$P = \int_0^{2\pi} \int_0^{r_0} \mu\, p\, dr\, r\, d\theta \cos\phi \quad . \quad (2)$$

The position of the instantaneous centre may be found from (1) and the tractive effort from (2).

ELEMENTARY ANALYSIS

A more elementary analysis, using the same principle as in the basic analysis above, is as follows:

In Fig. 7, neglecting curvature and inclination, let the forward velocity of the skid-wheel be represented by OA. If the instantaneous centre of rotation is at I, the relative velocity of any point on the skid-wheel will be proportional to its distance from I, thus the velocity of point B relative to the ground is represented by BD. Point B is moving forward over the ground in the same direction as O, that is, in the direction of tow. Point F is moving backward with velocity proportional to FE, and point G is moving in direction GS with a velocity proportional to GN ($= G_1 H_1$). All points within the contact circle are moving with velocities considerably less than OA, the speed of tow, and some are opposing and some are assisting the required motion.

The resultant frictional force resisting motion at an elemental area as shown at G will act in the straight line SG, and have a turning moment about O equal to the force multiplied by OS. This moment will be in a clockwise direction. At J the velocity is represented by JK, and the turning moment of the force at this point, about O, is equal to the force multiplied by OL. This moment is in an anti-clockwise direction. If a circle be drawn with OI as diameter, it is evident that forces acting on its circumference, e.g. at M, will have zero turning moments about O. All the forces acting on one side of this circumference, i.e., within the crescent PIQF, will have clockwise moments, and the forces acting on the other side, i.e., in the area PBQI, will have anti-clockwise moments, about O. Since there is no resultant torque at O (the skid-wheel is free to rotate), the position of I must be such that the sum of the clockwise moments equals the sum of the anti-clockwise ones.

A method of determining the position of I is therefore to find, by trial and error, the position which produces an equal summation of clockwise and anti-clockwise moments. This may be done by dividing the contact circle into a reasonably large number of parts, measuring the appropriate quantities, and making an algebraic summation.

Referring to Fig. 8, if p is the bearing pressure per unit area (assumed constant), a is the area of element ABCD, μ is the coefficient of sliding

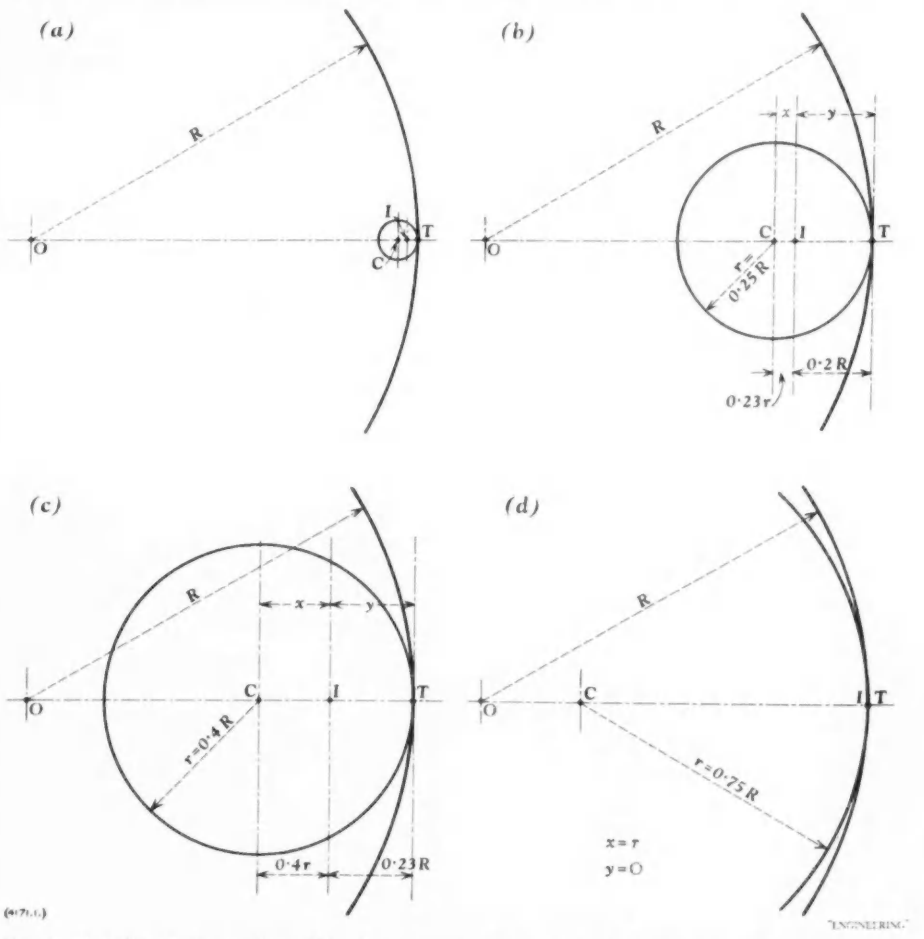


Fig. 9 Variation in the position of the instantaneous centre I with different sizes and positions of the contact circle. R = skid-wheel radius, r = contact circle radius.
(a) r = very small. (b) r = 0·25 R. (c) r = 0·4 R. (d) r = 0·75 R.

* For this the author is indebted to Dr. D. M. A. Leggett of London University.

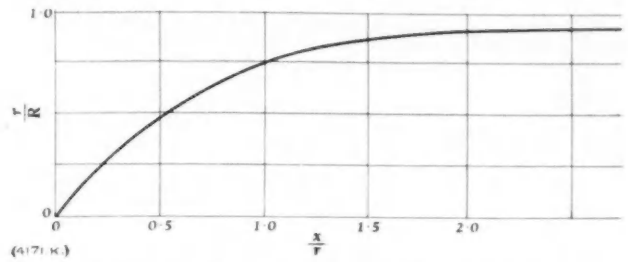


Fig. 10 Variation of the distance between the centre of the contact circle and the instantaneous centre with contact circle radius.

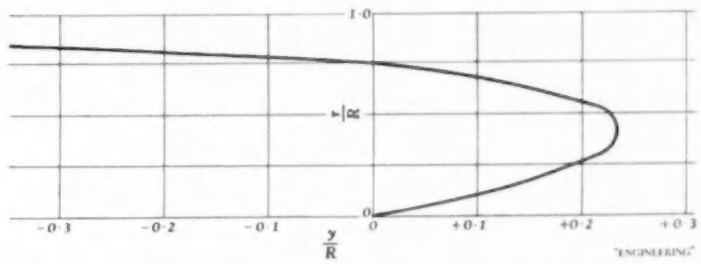


Fig. 11 Movement of the instantaneous centre relative to the centre of the skid-wheel, as the contact circle radius is varied.

friction between the ground and the skid-wheel surface, x is the perpendicular distance from O to the line of action of the force F, acting on area ABCD, then:

$$F = \mu a p$$

and the moment of F about O $= \mu apx$. If the correct position of I has been chosen:

$$\Sigma \mu a p x = 0$$

or, if μ and p are constant

$$\Sigma a x = 0.$$

Thus, by trying one or two positions of I, its true position may be estimated with fair accuracy.

Having found the position of I for any given size of contact circle and skid-wheel, the tractive effort may be estimated graphically by summing up algebraically the forces acting on as large a number of elements of the area as practicable, resolving in the direction of tow: thus, the total tractive effort required to overcome the frictional force acting in the direction of tow is:

$$\Sigma \mu a p \cos \phi$$

This may then be compared with the effort needed to drag the whole area as a plain skid, $\mu A p$. For the case when the ground contact circle has a diameter equal to two-thirds of the radius of the skid-wheel, and is coincident with it at T, the ratio worked out to about 1 to 4.

APPENDIX II

Variation in Position of Instantaneous Centre

It is interesting to observe the variation in the position of the instantaneous centre I with different sizes and positions of the contact circle. Fig. 9 shows what happens as the contact circle, assumed for simplicity to be always coincident with the skid-wheel periphery at T, increases in size.

If the contact circle is small, as at (*a*), I is obviously very close to its centre C. When its radius r is one-quarter that of the skid-wheel R, as at (*b*), I is found to have travelled radially inwards from T by an amount equal to approximately 0·2 R.

When the contact-circle radius is between a third and a half that of the skid-wheel, as at (*c*), I has moved inwards to its maximum extent, about 0·23 R. Thereafter, as the contact circle increases further in size, the position of I recedes, and when $r = 0{\cdot}75$ R it has returned to a position on or near the rim (*d*). When the contact-circle radius is greater than about 0·75 R the instantaneous centre lies outside the skid-wheel and, in the limit, when $r =$ R, I will be at infinity and rotation will not occur.

Fig. 10 shows how the distance x between the centre of the contact circle and the instantaneous centre increases as the contact circle grows in size. Fig. 11 shows the movement of the instantaneous centre, first towards the centre of the skid-wheel and then away from it. The apex of this curve probably indicates where the efficiency of the device begins to fall off rapidly, or the diameter of the contact circle above which the frictional forces increase unduly with decreasing bearing pressure.

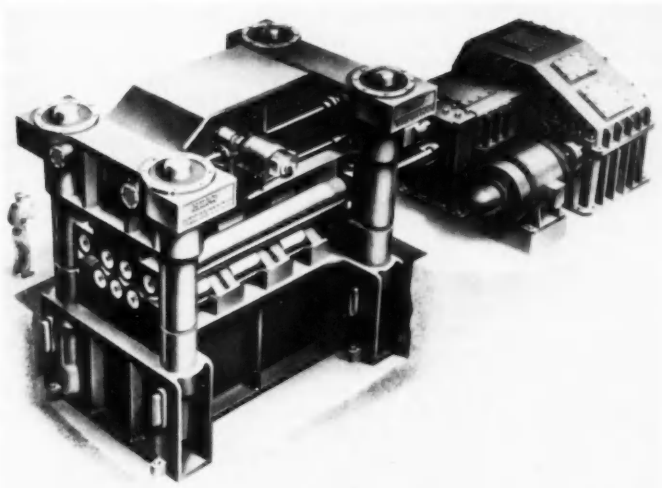
LEVELLING HEAVY STEEL PLATE

To meet the increased demand for heavier steel plate in shipbuilding, especially for tanker construction, Swan, Hunter and Wigham Richardson, Limited, Wallsend-on-Tyne, are to install a new heavy-duty roller-type levelling machine. The average length of plate to be handled is about 25 ft., and the machine has been designed to deal with this plate in the minimum possible number of passes, so increasing output. The machine will be able to handle plate up to 2 in. thick and 12 ft. wide.

To meet the required range of plate thicknesses, and at the same time to cut down the number of levelling passes, the designers and builders of the machine, the Head Wrightson Machine Company, Limited, Middlesbrough, have kept the levelling roll diameter down to 15 in.; this has been done by using three banks of backing rolls across the face width of the levelling rolls.

There are seven rolls, four in the top assembly and three in the bottom; all of them are 15 in. diameter except the two top outer rolls, which are 18 in. diameter, and act as entry and exit rolls. The whole beam carrying the top rolls is provided with screw-down gear, and the two outer rolls are independently adjustable. All the rolls are of hardened alloy steel. Their settings are shown on wide-scale indicators.

A 350 h.p. alternating-current motor gives a levelling speed of 15 to 30 ft. per minute, it being possible to increase this figure to suit particular requirements. The five centre levelling rolls are individually driven from a totally-enclosed triple-reduction gearbox, through universal-joint type spindles. The two top outer rolls are idlers. Control is by push-button, there being duplicate control stations, one each side of the machine to allow the operator to make fine adjustments of the outer rolls in either forward or reverse direction. A floor-mounting contactor panel houses the gear for starting, running and protection of the equipment, and push-buttons for the main controls are mounted on this panel.



Steel plates up to 2 in. thick, 12 ft. wide and 25 ft. long can be handled by this heavy-duty leveller built by the Head Wrightson Machine Co. Ltd.

★ ★ ★

MALAYAN MAIN LINE DIESEL ELECTRIC LOCOMOTIVES

The first of 20 main line Diesel-electric locomotives was recently handed over to the general manager of the Malayan Railway, Mr. C. G. Harrison. Manufactured by the English Electric Company, Limited, Marconi House, Strand, London, the locomotives are to play their part in the programme of improvements to the main line service from Singapore to Kuala Lumpur and Prai—a distance of 488 miles.

The 96 ton locomotives develop 1,500 h.p. and are capable of hauling 450 ton passenger trains. Attention has been paid to the particular conditions found in Malaya. The floor plate of the underframe is unbroken throughout its length to prevent the entry of dust from the track.

The bogies have been designed with regard to the sharp curves that occur on the metre-gauge track. In addition to swinging link suspension, spring gear is incorporated between the bogie frame and the wheels and also between the bogie frame and the superstructure.

The locomotive superstructure is carried on two three-axle bogies. Each axle carries a nose-suspended traction motor driving the wheels through a single reduction spur gearing. The streamline nose compartments, in front of the full-width driving cabs at each end, house the traction-motor blowers and exhausters. The Diesel engine is directly coupled to the main generator, being supported on flexible bearers to relieve the engine bedplate of stresses which might otherwise develop. Operating at 850 r.p.m., the engine has 12 cylinders arranged in two banks with an included angle of 45 deg. and is exhaust gas turbo-charged.

★ ★ ★

PRECISION GUN REAMERS COMMERCIALLY AVAILABLE

Gun reamers of the type developed by Short Brothers and Harland Limited, Belfast, in perfecting the new machining technique which the company announced recently (ENGINEERING, January 25, page 116, 1956), will shortly be available to the engineering industry.

Known as the Short-Serco gun reamer, they will be marketed by Serco Limited, of 387 City road, London, E.C.1.

Under the agreement Serco Limited are arranging for manufacture of the reamer to Short's specification and will be solely responsible for its distribution.

FOR FUTURE SHIPS

NEW HYDRODYNAMICS LABORATORY FOR N.P.L.*

By J. F. Allan, D.SC.

Various early efforts had been made to relate the results of ship model experiments to full-scale performance, before the first effective results were obtained by William Froude in a tank completed at Torquay in 1871. Its dimensions were 278 ft. by 36 ft. at surface by 10 ft., and the experiments carried out there for the Admiralty were of great practical and historical significance. The Torquay tank was dismantled in 1886 and a new tank, 400 ft. by 20 ft. by 9 ft., which is still in operation, was opened by the Admiralty at Haslar in 1886 to continue the work. In the interim period in 1882 William Denny and Brothers, Limited, of Dumbarton, built a tank 249 ft. by 22·4 ft. by 8·75 ft. which is to-day the oldest tank still in active use.

FIRST N.P.L. TANK

In this country in the early years of this century the need for a national establishment available for the work of any shipbuilder was appreciated, and by the generosity of the late Sir Alfred Yarrow, a tank 494 ft. by 30 ft. by 12·3 ft. was opened at the National Physical Laboratory in 1911, under the auspices of the Royal Society and with the support of the Institution of Naval Architects. The late Dr. G. S. Baker was in charge of this establishment from 1910 until 1942. In the early years funds for research were provided by the industry, but when the Department of Scientific and Industrial Research was set up in 1917 the situation began to change and gradually most of the funds for research were provided from official sources. The Research Fund was not abandoned, however, until 1948, when it was decided to spend the balance by awarding Froude Research Scholarships under the Institution of Naval Architects.

In 1931-32 a second tank, 680 ft. by 20 ft. by 9 ft., with carriage speed up to 30 ft. per second, was built at Teddington. It is reduced in depth to 2 ft. (or less as may be required) for 200 ft. from one end and is also provided with a removable bulkhead 130 ft. from the same end. This tank is of great value for testing propellers, high-speed boats and many special investigations. In 1936 a water tunnel was completed at Teddington, thanks largely to the generosity of the late Sir James Lithgow.

In 1945 the demand from shipbuilders for resistance and propulsion tests was such that there was a nine months' delay in putting work in hand leaving practically no effort available for research. The main facility for research on hydrodynamic problems for merchant ships in this country was still the original tank built in 1910. Many more up-to-date facilities had been built in other countries. A panel was appointed under the chairmanship of Dr. Ramsay Gebbie to look into the matter and make recommendations. After careful consideration it was proposed to build a tank 1,800 ft. by 50 ft. by 25 ft., providing a steady run of about 700 ft. at 50 ft. per second. It was intended that the main tank be provided with a removable bulkhead at mid-length and two carriages, one for 50 ft. per sec. and one for 25 ft. per sec. It was also recommended that provision should be made as soon as possible for a steering pond, a circulating water channel, a large water tunnel and a shallow-water tank.

The main proposal was accepted in 1946, and the search for a suitable site within reasonable distance of Teddington was begun. In 1950 a suitable site at Feltham, Middlesex, was inspected and approved.

At the end of 1952 the Ministry of Works prepared an estimate of cost based on the plans for the 1,800 ft. main tank, 44 in. water tunnel with resorber, small pond, workshops and offices. This estimate exceeded £3 million, and as £2 million was the target, consideration had to be given to reducing the cost. The conclusion was reached that the length could be reduced to 1,300 ft. and still give a useful steady run at 50 ft. per sec. with a lightweight carriage and a fairly severe braking system. This cut in length, combined with above-ground construction, a reduction in breadth to 48 ft., and various other economies, brought the estimate within the £2 million budget.

The Ministry of Works prepared detailed designs and drawings in consultation with the Ship Division, N.P.L., and the main construction contract was let to Sir Robert McAlpine and Sons, Limited, in 1954. The structure of the main tank, and the main building, will be substantially complete, and the tank filled with water, by this summer (1957), and the whole project should be in full working order by the spring of 1959. A model of the complete establishment is shown in Fig. 1.

Fig. 1 In the new ship-model laboratory there will be a main tank 1,300 ft. long and a manoeuvring tank 100 ft. square.

THE MAIN TANK

The cross-section of the tank depends on the size of models, and the length depends on the maximum speed. The size of model is determined partly by questions of model Reynolds number and laminar flow, but more by the desirability of avoiding material scale effects in model propellers and hull appendages. On these counts the present N.P.L. normal size of model, around 18 ft., is reasonably adequate for single screw vessels unless the propeller is of very low pitch and high r.p.m., but is not adequate for twin or multiple screw designs.

Accepting a model length of about 24 ft., a typical beam would be about 3·2 ft. and draught about 1·3 ft. This gives a midship section for a full form of around 4·0 sq. ft. Recent researches have shown that boundary interference is within acceptable limits of experimental accuracy if the model midship section is less than 0·4 per cent. of the tank section. This leads to a tank section of about 1,000 sq. ft. It was decided to adopt a section 50 ft. broad and 25 ft. deep to allow a margin for larger models and this was subsequently cut to 48 ft. by 25 ft. in the interests of economy The depth gives a wave of translation speed of about 28 ft. per sec. so that displacement models should not show any bottom interference below about 15 ft. per sec.

The length of tank depends on the top speed, the duration of run at that speed and the acceleration and deceleration which can be achieved or are acceptable. High-speed craft require model speeds up to 30 ft. per sec. in the present No. 2 tank at Teddington, and these models are too small for propulsion experiments. Allowing for larger models and future development, a top speed of 50 ft. per sec. was specified. Such a speed is unnecessary for normal ship work, for which 25 ft. per sec. is adequate. As has been indicated, the two-carriage scheme was scrapped in the interests of economy, and it thus became necessary to design the single carriage for a top speed of 50 ft. per sec. Automatic recording dynamometers will be used.

With dry polished steel on steel and using the track wheels only, an acceleration and deceleration of at least 0·1*g* can be achieved without risk of wheel slip. Consideration was given to the use of solid rubber-tyred wheels (which would permit a higher acceleration), but for the loads arising from even the lightest carriage that could be built to span 50 ft. the proposition was impracticable.

For normal model work (up to say 20 ft. per sec.) regenerative braking on the track wheels will be used, and for higher speeds an air-hydraulic system with brake shoes engaging brake rails has been adopted. The total deceleration with both systems is 0·25*g*. Emergency braking by arrester-type gear giving an average of 0·65*g*. will also be installed.

On the basis of these figures we have for 7 seconds at 50 ft. per sec.:

Length of carriage	50 ft.
Acceleration to 50 ft. per sec. (max. 0·1*g*.)	say 590 ft.
Steady run	say 350 ft.
Deceleration (0·25*g*. max.) ..	say 200 ft.
Emergency stop (0·65*g*.) ..	say 85 ft.
Beaches and wavemaker ..	25 ft.
Total	1,300 ft.

For 20 ft. per sec. and normal deceleration the 1,300 ft. length will give over 1,000 ft. of steady speed. This will allow reasonable time to study phase change in pitching experiments, will be a great advantage in pressure and flow investigations, and will also enable a normal resistance or propulsion test to be completed over a range of speed in very few runs.

It was originally intended to excavate the tank below the ground level. The subsoil consists of about 15 ft. of gravel with London clay beneath. The water table is some 4 ft. below the top of the gravel and it would have been necessary to sheet-pile or chemically freeze the entire perimeter of the excavation to keep water out. By building the tank above ground level a very substantial saving in estimated cost was achieved. The waterway is on the north side of the main building and runs east and west. The assembly area, with trimming docks, cranage, and access arrangements, is at the eastern end,

* "The National Physical Laboratory New Hydromechanics Laboratory," by J. F. Allan, D.Sc. Superintendent, Ship Division, N.P.L. Paper read at the Spring Meeting of the Institution of Naval Architects, London, March 27, 1957. (Abridged.)

adjacent to the office and workshop areas, and the normal direction of running is from east to west.

WATERTIGHT BY EXPANSION

The waterway is built up of 22 reinforced concrete monoliths, about 57 ft. in length. These were cast in line on the preliminary over-site concrete, leaving jointing gaps about 3 ft. wide. To ensure final tightness when the tank is filled and the normal maintained temperature has been reached, the fabric of the tank should be in compression. The joints have therefore been cast during January and February of this year at a temperature of 45 deg. F. or less, allowing a rise of 15 deg. to the nominal water temperature of about 60 deg. The completed waterway has a base slab 81 ft. wide and 4 ft. thick in way of the walls. The walls are 24 in. thick at the base, tapering slightly on the outside to the top, which carries a shelf projecting on the outside and forming a platform 30 in. wide as a seating for rail chairs and brake rails. The walls are supported by external buttresses which carry a walkway 6 ft. wide along each side of the tank. The inside surfaces were cast to a very smooth finish by the use of plastics-faced shuttering. The monoliths at the east and west ends include the end walls of the tank, which are also buttressed externally, that at the west end being strengthened to take not only hydrostatic loading but also the reaction forces set up by the wavemaker. At the east end the buttressing forms part of the structure supporting the trimming docks and the platform providing access to the carriage. The arrangement is shown in Fig. 3. The platform is 19 ft. above floor level, access being obtained by a stairway and a lift. Two trimming docks are provided, the larger being 40 ft. by 8 ft. wide by 4 ft. deep and lying on the centre line of the tank. The transfer dock at ground level is an extension of the model storage area and models will be lifted from here to the trimming docks by an overhead crane spanning the assembly area. This crane has a capacity of 5 tons.

The building housing the tank consists of the assembly area (a large rectangular hall covering the limits of travel of the overhead crane) and the portion covering the main tank (a light frame structure carrying a barrel roof). The assembly area is 60 ft. high, 70 ft. wide and 185 ft. long.

The assembly area and the tank building are frame structures, clad externally with corrugated asbestos and internally with aluminium-faced insulation slab. The roof structure is of aluminium alloy with an insulating decking having external layers of bituminous material, a filling of cork, and aluminium alloy internal cladding. Over the tank, strong daylight and especially direct sunlight are undesirable, as these encourage marine growth. On the other hand, the effect on the staff of working in a "tank in a dark tunnel" is bad, and a certain amount of daylight makes observational and photographic work very much easier. The natural lighting has been limited to a continuous line of windows high up on the north side of the tank building.

Considerable attention is being paid to the maintenance of even temperatures throughout the tank building. The heating and ventilating units are housed in five towers, three on the north side and two on the south, external to the main tank building. These towers carry staircases giving access to the lower passage through the buttresses, and those on the north side also give access to observation rooms having windows in the tank wall just below water level for study and photography of underwater phenomena. In the central position a low-level slit window is also provided.

Electrical supplies to the carriage are carried by low-level conductor rails in recesses along the outside of the tank wall adjacent to the walkways, these being protected by a guard rail.

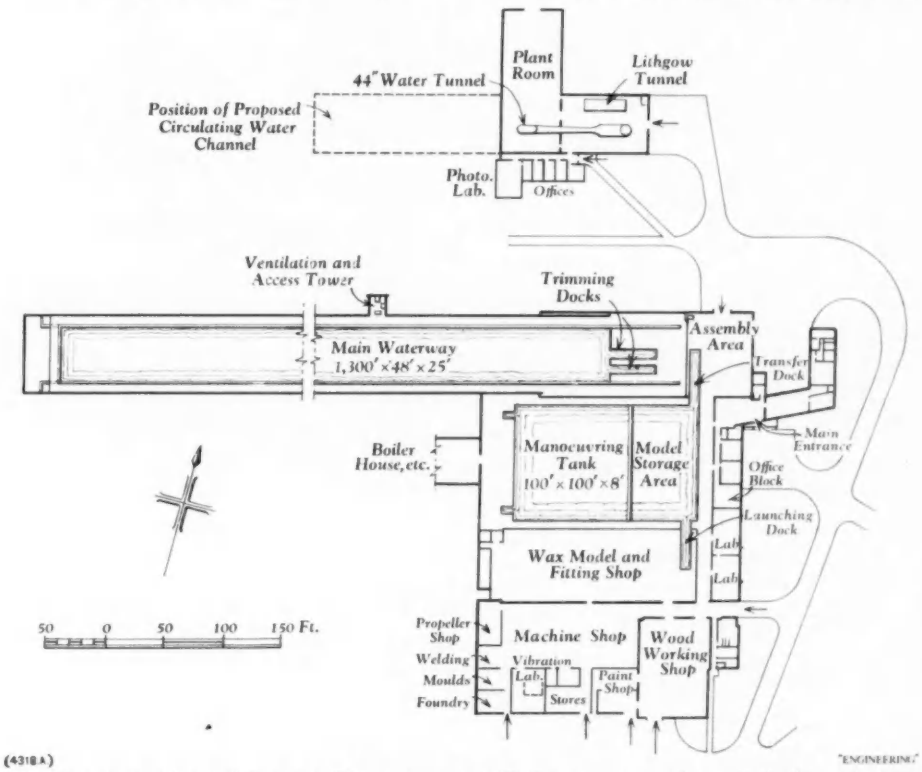


Fig. 2 Plan of the buildings. A 7 seconds run at 50 ft. per sec. can be made in the main tank.

WELDED RAILS

The rails are of a special heavy section, rolled at 260 lb. per yard. The rolled section was machined and heat treated in 30 ft. lengths and thereafter welded into 60 ft. lengths. The final machined section weighs 216 lb. per yard. The 60 ft. lengths will be laid on chairs at 42 in. nominal centres and welded to form continuous lengths. A special machine has been developed for planing the joints *in situ*. The chairs were designed to permit adjustment both vertically and laterally to facilitate alignment to the fine tolerances necessary to ensure steady running and absence of vibration.

Waves arise in the tank from two sources: the pattern of transverse and diverging waves generated by a model, and the pattern of transverse waves deliberately generated by a wavemaker for rough water studies. For both patterns damping must be provided, but the nature of this differs. It is necessary to still the water as rapidly as possible after the passage of the model to minimise the interval between runs. In the second case it is essential that minimum damping should occur during the passage of the wave, but that on reaching the opposite end of the tank it should be damped so that no significant wave is reflected. Efficient beaches will be provided across each end of the tank. At the dock end this will be arranged so that it can be readily lowered below the level of the bottom of the dock. At the wavemaker end the beach will be in front of the wavemaker, and arranged so that it can be readily lowered to the bottom of the tank.

The decay of the diverging wave pattern is considerably accelerated if beaches are fitted along the sides of the tank. This has a further advantage. For economic reasons, and for convenience of access, it is usual to make models, intended only for still water experiments, with a minimum of freeboard. At high wavemaking speeds the wave pattern generated by the model in the tank may, if undamped, be of sufficient magnitude to damage or swamp the model at the end of the run. When the wavemaker is in use the side beaches must be removed. High efficiency of side beaches is not important and a hinged flap arrangement is being provided along the entire length of each side of the tank.

The beach fitted in 1947 at the dock end of the Yarrow tank has proved very satisfactory and forms the basis of the design of the main beaches at Feltham. It takes the form of a portion of an exponential surface intersecting the water surface at an angle of 5 deg. and terminating about 5 ft. below the surface. The part below the water consists of slats of greenheart laid edge to edge, while in the region of the water surface and for some way above it, the slats are separated by gaps. The submerged portion causes the approaching waves to break on the beaches, and the backwash, which might result in the generation of secondary waves, escapes through the gaps.

In the design of the side beaches, cost and ease of operation were considered to be of prime importance. Since these beaches will total 2,400 ft. in length, either elaborate lifting gear would be required or the beaches must be light and easily lifted so that manual operation is practicable. The latter consideration has been adopted. The beaches are curved flaps 2 ft. wide hinging from a point about 3 in. above the water surface and extending in the down position about 6 in. below the surface. In the raised position the beach lies against the tank wall, presenting a smooth flat surface to a height of 15 in. above the water surface. The beaches are made of resin-bonded glass fibre, in 7 ft. lengths, each length having two hinges and a central locking lever. A single arm lift will raise the lever and lock it in the up position.

WAVE GENERATOR

The wavemaker in the main tank is required to generate a uniform train of parallel waves of up to 40 ft. by 2 ft. high, i.e., 1 : 20 height to length. It is the practice at the N.P.L. to measure wave forms from the carriage so that the waves actually encountered by the model in its passage up the tank are recorded. This practice has brought to light considerable variations in height resulting from interference effects, and measures have been sought to minimise these.

There are a number of practicable methods of producing the desired displacement of water and all these have been considered. The main categories are: (1) piston wavemakers in which the end of the tank or an internal vertical surface parallel to the end of the tank is displaced horizontally; (2) flap wavemakers in which a vertical flap is pivoted about a submerged axis; (3) plunger wavemakers in which a suitably

shaped plunger is displaced vertically; (4) pneumatic wavemakers in which water is displaced from an inverted bell by applying a varying air pressure within the bell.

Model studies and theoretical considerations have suggested that a deep wedge plunger having a hollow face of more or less exponential form is likely to give the most satisfactory results, and this form has been adopted. The plunger is fabricated in steel and is guided on rails fixed to the end walls of the tank, the slides consisting of "Ferro-bestos" pads running on stainless steel surfaces. The plunger is displaced vertically by hydraulic rams driven by a pump which operates on an approximately sinusoidal pressure cycle. The motion of the plunger is monitored electrically in respect of amplitude, frequency and form, servo-operated valves correcting the main plunger motion accordingly.

CARRIAGE PROBLEMS AND DESIGN

The ship tank carriages at the N.P.L. were intended primarily for towing models along the central axis of the tank. While this function is a major one, the overall requirements in a research establishment such as this are much wider. The demands made by industry, research associations, Service departments, and internal research and development programmes require facilities for studying a wide range of hydrodynamic problems. These studies may include submerged phenomena; photographic and cinematic recording; wave, flow and pressure measurements; interaction phenomena, etc.; and though with improvision a great deal has been done at Teddington, the carriage structures are not really suitable, there being too many structural members impeding observation.

The new carriage design is based on the requirement of a rigid steady instrument platform offering the maximum access to, and visibility of, the water surface, and the maximum adaptability consistent with structural soundness. The lay-out is shown in Fig. 4. The basic conception of the plan is the provision of a rectangular frame about 50 ft. by 50 ft. enclosing an open bay 36 ft. by 36 ft., in which most of the experimental work will be carried out. This frame is a complete structure, and carries the wheels, brakes, propulsion and control gear. It is a triangulated framework basically of steel tube, consisting of two transverse girders spanning the tank, connected at their ends by two longitudinal girders. A continuous gangway or observation platform runs through the centre of these members and allows passage round the whole framework. Normal dynamometer equipment is carried on a beam of similar construction spanning the open bay in the longitudinal direction, but this beam is not integral with the main structure. It can be moved laterally to a number of positions across the bay, or removed completely.

The major vertical loads are imposed by dynamometer and other equipment, by non-buoyant towed bodies, and by bodies which produce hydrodynamic lift. In addition there are the weights of structure, propulsion and control units, and so on. The major horizontal loads are imposed by acceleration and deceleration and the limiting load is that imposed by the maximum emergency braking rate of $1{\cdot}3g$. Apart from this last consideration, the stressing of the structure is low. A major requirement is stiffness and freedom from vibration. For this span, at the specified central load, it has been calculated theoretically that the carriage cannot have a fundamental vertical frequency in excess of 10 c.p.s.

The propulsion units consist of steel frames carrying the motor, the gearing and two 27 in. wheels with centres 28 in. apart. The frame also carries two pairs of vertical guide rollers running on the side faces of the rails, so that the whole propulsion unit is self-guiding. Each unit is connected to the carriage structure by flexible links allowing slight rotary motions about transverse and vertical axes lying in a vertical plane midway between the wheel axes.

At the top speed of 50 ft. per sec. the specification calls for 100 h.p. to be available for model towing, allowing for a maximum drag of 1,100 lb. The wind resistance of the structure is estimated from wind tunnel experiments to require 200 h.p. at the top speed. The overall power to accelerate and run the carriage, covering mechanical friction, accelerating loads, and a margin to allow precise speed control, is 300 h.p. per unit, or 1,200 h.p. in all. Electronic speed control giving repeatability and speed holding to 0·1 per cent. of full scale throughout the range is called for.

BRAKING SYSTEM

Smooth and safe braking is essential, and three systems are provided, regenerative, track and emergency. At speeds up to about 20 ft. per sec. the use of regeneration provides a smooth deceleration at $0{\cdot}1g$, though it may be necessary to use the track brake to provide a dead stop. At high speeds, or in emergency, this is reinforced by the application of opposed brake shoes to vertical brake plates along the tank walls. These shoes are applied by hydraulic pressure using an air-hydraulic system with a failure to safety. The combined track and regenerative brake is designed to give a maximum deceleration rate of $0{\cdot}25g$. This system is available under manual control at any point on the run, but is applied automatically by a track trip at a suitable distance from each end of the tank. In the event of a partial or total failure of these systems, hooks on the carriage pick up cables connected to a hydraulic arrester gear giving an emergency deceleration of $0{\cdot}65g$. No arrester gear is provided at the dock end, but the electrical control limits speed on the reverse run to a maximum of 10 ft. per sec., and beyond the normal stop position only "inching" speeds are available.

The main carriage flooring and fixed working platform are about 3 ft. above water level, and the two end transverse members of the dynamometer beam are cranked up in the middle to give additional clearance. This general level of 3 ft. is convenient as a instrument platform, but is too high for many observational experiments, and the dynamometer beam therefore carries on its south side a platform 24 ft. by 2 ft. 6 in. wide which can be lowered on screw jacks to water level for photographic and observational work. The windows admitting daylight to the tank building, and those in the walls of the waterway, are on the north side of the tank, and fixed photographic lighting and camera positions will be provided on the carriage on the same side. The fixed working platform is therefore placed so that a clear view of a towed model can be obtained under it, while the adjustable platform is on the south side.

Compressed air for brakes and other applications is stored in bottles, as the weight and vibration of built-in compressors is undesirable. Lighting is provided mainly by fluorescent tubes.

MANOEUVRING AND STORAGE TANKS

The original proposal included a tank 160 ft. by 100 ft. by 8 ft. deep which would be used partly for storage of models, and partly for manoeuvring experiments. When it was decided to plan for wavemakers to be fitted, it was clear that stored models must be protected from damage and a wall was built dividing the tank into a manoeuvring area 100 ft. by 100 ft., and a storage area 60 ft. by 100 ft. The wall has a gangway along the top and a gap adjacent to the south wall so that passage can be allowed for models. This gap will be closed when necessary by a floating gate.

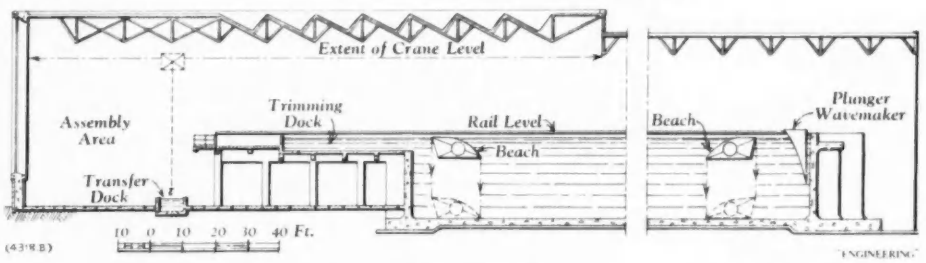


Fig. 3 Longitudinal section through main tank.

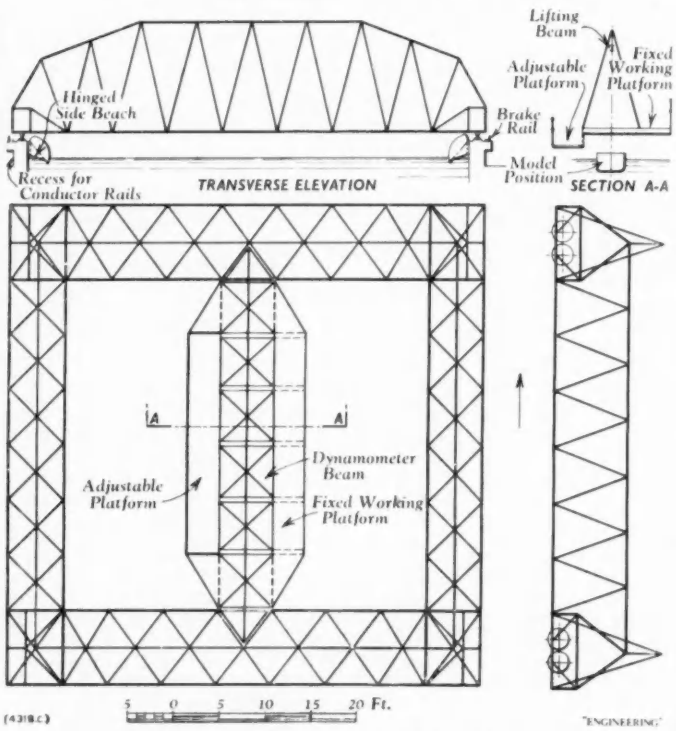


Fig. 4 ▲ Diagrammatic outline of carriage.

The manoeuvring tank has the west and south walls strengthened and fitted with mounting bolts for plunger-type wavemakers, and the east and north walls prepared for the mounting of beaches. It is intended to provide at once a continuous plunger-type wavemaker on the south wall and a beach on the north wall. This wavemaker will produce waves up to 15 ft. long and 9 in. high and will be operated mechanically by an adjustable crank system through gearing from an electric motor. As soon as possible a further plunger-type wavemaker, of an articulated design, will be provided on the west wall and a beach on the east wall. This will enable diagonal seas to be superimposed on the main pattern.

The manoeuvring area has two small docks for fitting up and trimming models. The building is of similar general construction to the main

tank building and the same conditions apply to insulation, heating, and control of humidity. As the volume of water is relatively small, it is possible to consider the use of chemical inhibitors and even of changing the water if growth becomes excessive, and in the interests of photographic and other work daylight has not been reduced.

It is intended to use free running models in this basin. As a preliminary the Ship Division, N.P.L., introduced a system of radio control for free models some years ago. This was developed in conjunction with Vickers-Armstrongs (Aircraft) Limited, Weybridge, and provides a link between a shore control station and the helm and engine controls on the model which is so direct as to be almost equivalent to a mechanical link. It is proposed to track these free models automatically, and development work on this proposition is in progress in the Control Mechanism and Electronics Division of the N.P.L. As envisaged at present, the models will carry a suitable corner reflector, and light beams from two shore stations will locate this using a photocell following system, the position of the model being determined in terms of bi-polar co-ordinates. To avoid coincidence of the beams at very flat angles, the stations will be on the north and south sides of the storage area, east of the line of the dividing wall.

WATER TUNNEL

It was decided in 1948 to build a water tunnel for testing screw propellers up to 24 in. in diameter over a wide range of operating conditions of speed and pressure. It was known from experience with the Lithgow tunnel that there was little boundary interference when testing a 10 in. screw in the 18 in. square tunnel section. In the new tunnel it was decided to use a circular closed-throat test section having a diameter of 44 in. This gives a similar area ratio of disc to tunnel section to that for a 10 in. screw in the Lithgow tunnel. The tunnel will also be used for cavitation studies on hydrofoils and other fixed bodies, and at least two additional test sections are contemplated, one of which will be a guided jet arrangement. Existing water tunnels are normally de-aerated before carrying out tests in cavitating conditions, the air content being reduced to the order of 0·2 of saturation. If this is not done the water circulating in the tunnel rapidly becomes filled with a mass of bubbles. One simple way of putting air into solution in water is to subject the mixture of water and air to a sufficient pressure for a sufficient time. As there did not appear to be any other suitable means of re-dissolving the air, the design of the tunnel includes a deep resorber circuit, of large volume, so that the water velocity through it is low.

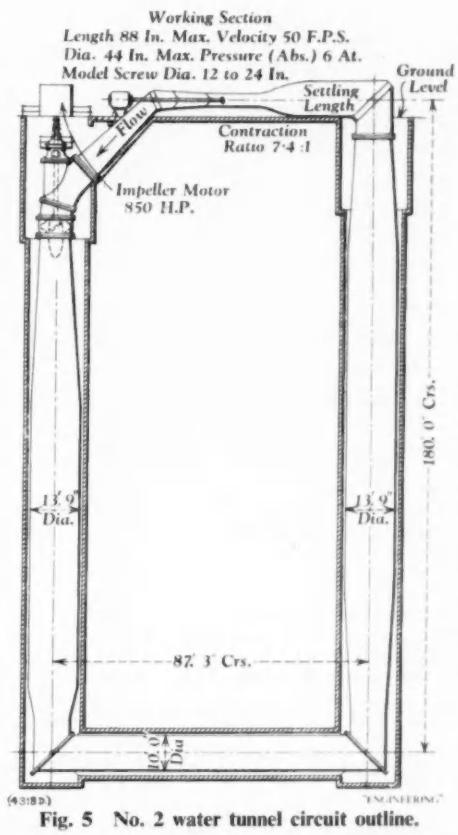


Fig. 5 No. 2 water tunnel circuit outline.

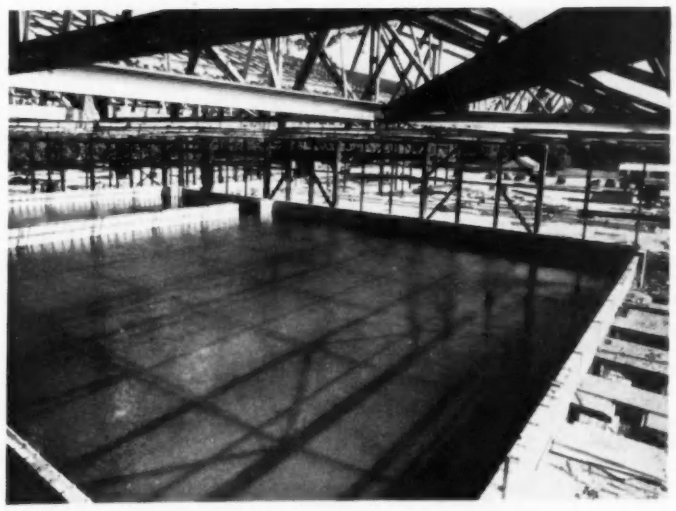


Fig. 6 The manoeuvring tank has a storage space at one end.

The arrangement adopted is shown in Fig. 5. The resorber circuit has a U-tube layout, the vertical limb being 180 ft. deep from the centre line of the test section to the centre line of the bottom limb, and the horizontal limb 87 ft. between the centres of the vertical limbs. This circuit is below ground level, which means that most of it is excavated in the blue clay. The upper part of the circuit has a short settling length after the 90 deg. mitred corner connecting with the resorber. This is followed by a contraction section of 7·44 area ratio 25 ft. long, leading to a closed jet working section 7 ft. 4 in. long. There is a transition section 4 ft. 6 in. long before the horizontal diffuser, which leads to a 45 deg. mitred corner and gives an expansion ratio of 2·0 from the working section. This corner is followed by a long diffuser at 45 deg., connecting with the other limb of the resorber at the impeller position.

The impeller pump is mounted vertically and this gives a pump head of 35 ft. to the centre line of the test section. The pump is of axial flow type and has a diameter of 92 in. It is provided with continuous speed and pitch controls to cover a range of flow rate from the maximum of 530 cusecs. down to 50 cusecs., the maximum power being 800 h.p. The flow direction can be reversed by varying the pitch. An accuracy of 0·1 per cent. of the set speed is specified down to 10 per cent. of full speed.

The model propeller shaft, of high tensile steel, is about 2·5 in. in diameter and 23 ft. long. It is fitted in the downstream side of the circuit and carried in three bearings, two on removable supports within the tunnel and the third in a boss at the 45 deg. bend. Arrangements have also been made to support a propeller shaft on the upstream side. The test screw is driven by an electric motor incorporated in the torque dynamometer. The normal maximum continuous rating is 300 h.p. at 20 revolutions per second, but a 25 per cent. overload for a limited period is specified, as well as rotational speeds up to 55 revolutions per second in both directions at lower torque. A short-term control accuracy of the order of 0·1 per cent. of set speed is specified over the main range of rotary speed.

It is intended to test propellers ranging from 12 in. to 24 in. in diameter at speeds from 15 revolutions per second for large propellers, to 55 revolutions per second for small propellers. The corresponding torque range is about 2,000 ft. lb. to 100 ft. lb., and a maximum thrust of over 5,000 lb. is allowed for. The dynamometer is a development of that for the Lithgow tunnel. The motor stator is supported on oil-lift bearings and the full thrust and torque loads are directly measured on hydraulic pick-offs, thus avoiding any deadweight loading except for calibration. The applied loads are determined by measuring the oil pressures in the appropriate hydraulic system on automatic indicating weigh-beams.

The speed of flow in the test section ranges from 10 ft. to 50 ft. per second and the pressure at the centre line can be varied from near zero to 6 atmospheres absolute. The tunnel is designed without any free water surface and pressure control is provided hydraulically. Two water ring pumps add or withdraw water to or from the tunnel circuit as required to maintain a set pressure in the test section. The pressure sensing element and control system are specified to hold the preset pressure to within ± 0·1 per cent.

An aeration and de-aeration plant is fitted to control the dissolved air content of the tunnel water. It operates in a by-pass circuit and is specified to be capable of reducing the air content of the tunnel water from saturation at atmospheric pressure to 0·2 of this value, or vice versa, in about 24 hours.

AUXILIARY LABORATORIES

In the main building the instrument development group have two laboratories, one nominally allocated to general instrument calibration, maintenance, and development, and the other to electronic work. Special photographic techniques are also required, especially in flow and cavitation studies, and a laboratory for processing, plan reproduction and copying, and experimental work, is housed in the water tunnel building. A laboratory in the main block has been allocated to the study of vibration, including entrained water effects. This is housed in the workshop area so that noise and vibration will not be transmitted to other parts of the building. The permanent equipment includes a water tank 20 ft. by 14 ft. by 6 ft. deep, and an overhead suspension grillage designed to have a very high natural frequency.

While the model hulls and propellers will still be made and tested by techniques similar to those used at the N.P.L., the models will be very much larger. The longest model hulls for which, on existing evidence, boundary interference should be negligible is about 24 ft., but for comparative work on propulsion systems, appendages, etc., very much larger models will be required. The workshops at Feltham have been planned on the basis of making model hulls in wax or wood up to 40 ft. in length and up to 7 ft. in breadth, and model propellers in bronze up to 24 in. in diameter, as well as dynamometers and other experimental equipment of appropriate capacity.

There are three large workshops and a foundry, mainly for the casting of model propellers. A propeller machining shop, a welding shop, and a paint-spraying shop are also provided, together with the necessary stores. A two-storey block in front of the main building accommodates the offices for scientific, administrative and clerical staff, record room, a library/lecture room, and the electronic and instrument laboratories.

Book Reviews

TRICKS OF THE TRADE

Modern Mathematics for the Engineer. Edited by EDWIN F. BECKENBACH. *McGraw-Hill Book Company, Incorporated, 330 West 42nd street, New York 36, N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (56*s.* 6*d.*)

Realising the need for enabling engineers to keep abreast of recent significant developments in the fields of mathematics and the physical sciences, the departments of engineering at the University of California took the initiative in arranging a series of lecture courses in modern aspects of physics, chemistry and mathematics for their staffs, students and graduates. Each course consisted of a series of invitation lectures delivered by prominent specialists, and these are being published as contributions to the University's extension series. The first two volumes dealt, respectively, with "Modern Physics" and "Modern Chemistry for the Engineer," the present one adds "Modern Mathematics" to the series. It contains the substance of 19 lectures, each delivered by a mathematician of distinction in the subject of his discourse, and has been edited by Professor Beckenbach of the department of mathematics in the University of California, Los Angeles.

The book is divided into three parts entitled, respectively, mathematical models, probabilistic problems and computational considerations. The first part deals with physical problems that admit of formulation in terms of ordinary differential equations, integral equations and partial differential equations. It opens with an account of linear and non-linear oscillations, in which representations in the phase plane are a prominent feature, and this is followed by a sketch of the stability theory of equilibrium states due to Poincaré and Liapunov. Some of the difficulties encountered in problems of exterior ballistics are considered next, these relating largely to the simplifying assumptions that have to be introduced to render the analysis manageable without altogether losing contact with reality. Chapter 4 summarises the elements of the calculus of variations and brings out clearly what is perhaps the chief advantage of variational principles, namely, that they are invariant and thus independent of the co-ordinate frame of reference. Professor Courant contributes, in Chapter 5, a beautifully lucid account of hyperbolic partial differential equations (which govern the phenomena of wave propagation) and of finite difference methods applicable where the occurrence of shocks introduces non-linear terms into them. Boundary-value problems in elliptic partial differential equations form a natural sequel to the above, with illustrations taken from fluid dynamics and electrostatics. The first part ends with a discussion of elastostatic boundary-value problems which includes formulation in terms of complex-variable theory.

The majority of engineers will find themselves on less familiar ground when they come to the second part of the book, but the growing complexity of technological development is tending to lay greater emphasis on stochastic rather than on deterministic behaviour. Professor Norbert Wiener begins with a good account of the theory of prediction, which serves to underline the essentially statistical nature of communication engineering but which presupposes a knowledge of the Lebesgue theory, of Fourier series and integrals and some acquaintance with the theory of functions of a complex variable. The theory of games, considered next, is fundamentally a theory of planning and is concerned with optimal courses of action. Various situations to which it is applicable are outlined and some of the technical and conceptual difficulties that arise in applying it are pointed out. This leads on naturally to applied mathematics in operations research, the ultimate goal of which is prediction with a rational rather than intuitional basis, and the main difficulty of which consists in identifying the significant parameters and in allocating approximate numerical values to them. Chapter 11 deals with three specific problems to elucidate the theory of dynamic programming. Chapter 12 is devoted to Monte Carlo methods, broadly defined as involving "the use of statistical sampling techniques to approximate the solution of a mathematical or physical problem."

More familiar ground is again reached in Part III, which is concerned with computational considerations. The engineer is primarily interested in numerical solutions to specific problems and here the whole outlook has been revolutionised by the introduction of high-speed machine methods. Professor Pipes starts with an admirable survey of the uses of matrices in engineering with special reference to elastic structure and electric circuit analysis, to wave propagation and mechanical vibration. This is followed by a brief general discussion of functional transformations for engineering design and a review of conformal mapping methods. Chapter 16 introduces some of the difficulties inherent in non-linear problems and some of the methods for tackling them. The query "What are relaxation methods?" which forms the title of Chapter 17, may sound somewhat strange to British engineers, but Dr. Forsythe eventually concludes that, in its wider sense, relaxation implies the approximate reformulation of broad classes of physical problems as systems of linear equations and, in its narrower sense, comprises a class of iterative procedures for solving them, characterised by the successive reduction to zero of the worst residual. Methods of steep descent, considered next, require multi-dimensional geometry for their treatment. The concluding chapter, devoted to high-speed computing devices, outlines the special features peculiar to analogue computers and to punched-card and electronic digital machines, and indicates some of their applications.

Some diversity in modes of exposition is inevitable when many topics are treated by a number of different authors but this in no way detracts from the overall interest of the work. Some chapters are confined mainly to general principles and theorems, others treat specific problems of direct concern to the engineer and show how they may be formulated so as to facilitate effective mathematical attack, while all are supplied with useful lists of references. This is a noteworthy book which presents most of the newer and more powerful mathematical tools and techniques now available to the engineer, and could profitably be recommended as preliminary reading for any engineer embarking on a post-graduate course of study.

On the Shelf

By Frank H. Smith

I have been taken to task for saying, in my last column (March 29), that references to solar energy are hard to come by. It would seem that my critic has hundreds, if not thousands, of such references. As it happens, he is in charge of one of the famous "closed shop" libraries and it would be useless, therefore, to let my readers know where those references can be found. This does not make them any easier to come by.

At a recent meeting of Aslib, Mr. H. C. Richardson of the library of the Institution of Civil Engineers gave an interesting talk on the changeover of that library from its old classification by shelf-notation to its present U.D.C. system. In ancient times this might have been classed with one of the less savoury labours of Hercules, but the job was accomplished with the minimum inconvenience to members and the maximum efficiency. The final step was approached with something akin to operational planning with the librarian as Chief of Staff and the rest of the I.C.E. staff as his troops.

It would be interesting to know the yearly birth-rate of technical libraries, but whatever it is there is a certainty that the librarian charged with the duty of bringing each new one into the world has to do a lot of thinking in preparing the bibliographical layette. His task is now considerably simplified with the publication of *British Scientific and Technical Books*, by James Clarke for Aslib. The price is 3 guineas.

This publication has been compiled from the *Aslib Book List*, which is well known to members of that Association whose submissions go to make its monthly issue. The *Book List* is selective and *British Scientific and Technical Books* is therefore the same; it does not contain every item on any given subject. It does, however, list most of the important books published from 1935 to 1952 and there is, as a consequence, a two-year overlap with the exhaustive *British National Bibliography*.

The titles are classified according to the Universal Decimal Classification and author and subject indexes make the finding of a particular book easy.

The uses to which punched cards can be put seem to be increasing day by day. Sometimes, for various reasons, they do not "come off" (the classification of aerodynamic data by the Nationaal Luchtvaartlaboratorium is still in the balance) but more often than not the cards are a success.

The European Productivity Agency of O.E.E.C. (3 rue André Pascal, Paris 16e) publishes pamphlets giving organisations in member countries likely to be useful to technical information services. The pamphlets cover Austria (37 pp.), Belgium (34 pp.), Denmark (39 pp.), France (61 pp.), Germany (54 pp.), Greece (21 pp.), Italy (45 pp.), the Netherlands (45 pp.), Norway (43 pp.), Sweden (35 pp.), and the United Kingdom (77 pp.). In a few weeks it is hoped that there will be a collected edition, suitably indexed, at a cost of about £1.

The International Council for Building Research Studies and Documentation (Bouwcentrum, Diergaardesingel 75, Rotterdam) produces, at 10 Florins each, ABC—Abridged Building Classification for Architects, Builders, Civil Engineers (F.I.D. Publication 261). These are multilingual extracts of the appropriate sections from classes 33·5, 6, 71 and 72 of the Universal Decimal Classification and, apart from their function for classifying documents, they form a dictionary by means of the decimal numbers. There are English, French, Norwegian and Swedish versions.

Evidence of the seriousness with which they take their technical libraries in America is given in a pamphlet "The Technical Information Library—Its Services and How to Use Them," issued by the Bell Telephone Laboratories. This is not a general treatise on technical libraries but is a beautfully produced pamphlet for the benefit of employees of Bell, telling them how to use the company's three main and six subsidiary collections. One company, nine libraries! The opening sentence—"Yours is the country's largest industrial research library"—must be very comforting for a scientist to read, and when he reads on and discovers the services that go with it he must count himself a lucky man indeed. Figures may be made to mean anything, but 100,000 volumes and 2,000 periodical subscriptions make many other technical libraries look silly.

FILTER FOR EASY SERVICING

A filter unit that can be serviced without the aid of any tools has been introduced by Plenty and Son, Limited, Eagle Iron Works, Newbury, Berkshire. It is designed initially for oil-firing and chemical-processing equipment, but can be used for many other purposes. The illustration shows the exterior of one of the Simplex models, together with the pipe connections. The cover is spigoted into the body, and is held in position by a hinge clamp and a hand-screw. There is an O-ring joint between the spigot and the body, there being a recess in the latter. To remove the filter element, the pressure of the hand-screw is released, and the pin which retains the clamp-head withdrawn, allowing the latter to be swung clear. The retaining pin has a flat formed in it, which, when engaged with lugs cast on the body and cover, is used to ease the cover off without damaging the joint. The filter element can then be removed by the handle that is fitted on the end of it.

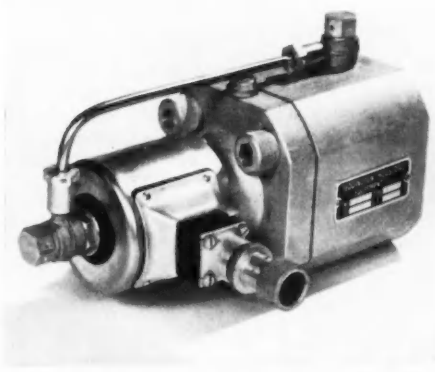
The position of the pipes on the filter unit is such that the liquid level is always below the cover, so that there is no spillage when the element is removed. Even for the maximum working pressure of 300 lb. per sq. in. the cover only requires hand tightening. It is self-locking. Standard sizes range from pipe bores of 2 in. to 8 in. and the filter surface is approximately 12½ times the pipe area. The normal perforations in the filter element are $\frac{1}{16}$ in. in diameter. Filters having finer or coarser elements, made in steel, copper, monel or other material are also available, as are models with bodies of cast steel, stainless steel or gunmetal. There are alternative bottom or side drains.

The Duplex filter consists of two standard Simplex units connected together by branch pieces which incorporate three-way cocks. This arrangement occupies slightly more space than normal Duplex units, but has the advantage of providing considerably larger liquid passages and less abrupt changes of direction. Consequently, the pressure drop is not so great. Also standard filter units are employed. The three-way cocks enable either filter to be isolated for cleaning, or both filters to be operated in parallel as required.

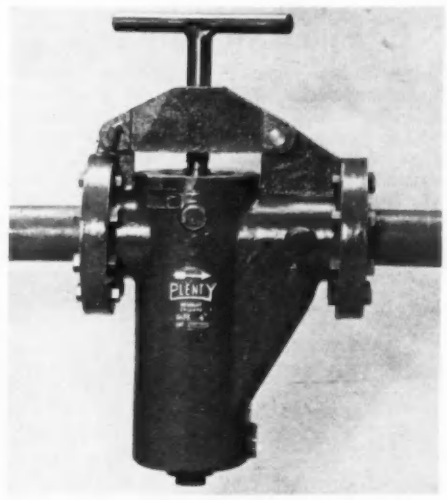
★ ★ ★

SOLENOID VALVE

Teddington Industrial Equipment, Limited, Sunbury-on-Thames, Middlesex, have introduced a solenoid-operated valve designed to handle large flows at high pressures. It is suitable for use in a wide range of hydraulic, pneumatic and similar applications. Operating pressures up to 1,650 lb. per sq. in. can be handled for most chemically-inert fluids or gases. The size range is from ¾ in. to 2 in. bore and the operation can be arranged so that the valve can either open or close when the solenoid is energised. The



By the use of a solenoid-operated needle pilot valve, the main piston valve can control large flows at high pressures.



Designed for quick servicing without tools, the cover of the filter is held in place by a handscrew and is above the liquid level.

valve, which is shown in the illustration, consists of two main parts, the solenoid-operated needle pilot valve and the piston-type main valve.

In the situation where the valve is required to open when the solenoid is energised, the armature is drawn up into the core and lifts the needle valve off its bottom seat. This relieves the pressure which has built up inside the piston, by allowing the fluid to escape to the outlet port. (A bleed-hole permits its entry into the piston in the first place.) Since the orifice of the needle valve is greater than that of the bleed-hole, an out-of-balance pressure is then exerted in an upwards direction, due to the fact that the piston has a greater area than the main valve head. This upward thrust is sufficient to compress the piston return spring and so the main valve is opened.

In the situation where the valve is required to close when the solenoid is energised, the bottom port of the servo valve is blanked off and the top port is connected to the main outlet. Therefore, so long as the solenoid is energised, there is no way in which the pressure built up inside the piston can escape. When the solenoid is de-energised, the top port opens and the internal pressure is relieved, thus allowing the main valve to open as before. The maximum pressure differential, as has been stated before, is 1,650 lb. per sq. in.; maximum working temperature 185 deg. F.; and the maximum viscosity of fluid that the valve will handle is 90 seconds Redwood No. 1. The solenoid is wound for 24 volts direct current.

★ ★ ★

COMPACT ELECTRIC MOTORS

A new range of general purpose squirrel cage induction motors, to be known as Mark IV, has been designed by Hoover (Electric Motors), Limited, Cambuslang, Lanarkshire, the objects being to conserve material and to reduce weight and size. These motors have a range of output from 1/10 to 1/4 h.p. at a speed of 1,425 r.p.m., and the cylinder of which they are formed is less than 5¾ in. in diameter, while the weight of the largest pattern is only 19 lb. Generally speaking, the dimensions conform to British Standard Specification 2048/1953 and the motors can in particular be made in flange-mounted pattern, which renders them of particular interest to manufacturers of oil burners and similar equipment.

Electrically the new motors conform to British Standard Specification 170:1939. The stator windings are insulated with synthetic material, which is impregnated on automatic equipment and is subsequently inserted in a steel shell which is machined to provide continuous registers for the aluminium die-cast end-frames. The rotor assemblies are statically and dynamically balanced to fine limits on electronic equipment. The bearing and lubrication arrangements are the same as those on the firm's existing Mark II motors.

Production has already begun on the 1/6 and 1/4 h.p. split-phase and capacitor-start sizes for all the standard voltages and these can be supplied with solid foot, resilient, NEMA and British standard flange mountings as well as with lug and "footless" mountings. It is intended to extend the range to cover three-phase motors and those running at other speeds.

★ ★ ★

FLOOR CLEANER

Inevitably floors become dirty and require cleaning. Equally naturally, mechanical devices have been developed for this purpose, and one of the more recent ones is the Mechocleen, introduced by Diamond Motors (Wolverhampton), Limited, Upper Villiers-street, Wolverhampton. Three machines, all of which are battery powered, make up the range, a dry scrubber and polisher, a wet or dry scrubber and polisher and a dryer. Being battery powered, they are free to operate at any part of the floor.

The two scrubbing machines can be adapted to different types of floor by changing the brushes. Those available range from sets with 90 ton tensile oil-tempered steel bristles for scouring impacted grease deposits, to polishing types with

The brushes on the battery-powered floor scrubber are arranged so that they can reach corners and wall edges.

bristles of nylon. The scrubber units, consisting of the brushes, ¾ h.p. electric motor, transporter wheels and handle bar, can be separated from the battery cradle and casters. This reduces the space required for re-charging the batteries, and also allows continuous operation of the scrubbers while spare batteries are being charged.

The brushes extend across the full 19 in. width of the scrubber head, and enable edges of walls and corners to be reached. On the wet scrubber, the machine shown in the illustration, there is a 4½ gallon capacity tank mounted on the handle-bar, with a variable feed control so that the fluid can be supplied at any rate from a trickle to a steady flow. The feed device sprinkles it in front of the oncoming brushes. An aluminium dust cover protects the gears between the electric motor and the brushes, and polyester glass fibre mouldings cover the motor unit and the switch mechanism. The dryer unit is designed to be used in conjunction with the wet scrubber machine in the vertical up-lifting of dirty water.

FIRE FIGHTING TENDERS

The use of foam is usually regarded as the best way of fighting oil fires. A tender and pump trailer for this purpose have been supplied to London and Thames Haven Oil Wharves, Limited, by Merryweather and Sons, Limited, Greenwich High-road, London, S.E.10.

The main task of the tender and trailer is to move foam compound and hose lines to any part of the wharf area to link up with the hydrant system already installed, and to provide a source of foam compound and water mixed ready for feeding to either foam generating fittings fixed to the storage tanks or incorporated in portable foam towers, or to hand-operated foam branch pipes. The machine chosen was from the Marquis range, driven by a 120 b.h.p. A.E.C. Diesel engine; the chassis has a short wheelbase for manoeuvrability. The appliance carries about 500 gallons of foam compound in a central tank, and a foam pump, running from an auxiliary power take-off on the side of the main gearbox, pumps the compound to the 180 ft. hose reel from either the tank or from drums. About 700 gallons per minute of water and foam solution can be provided which, with a generating equipment, can produce 5,000 gallons of foam a minute. The main pump will deliver 800 gallons of water per minute and the tender also carries six portable dry powder extinguishers.

For use at the Piarco airport, British West Indies, a crash tender has been designed to operate freely under adverse ground conditions such as would be met with in dealing with incidents off the runways. The 110 b.h.p. engine drives all four wheels of the vehicle. There is a main single-stage fire pump which is capable of handling 450 gallons of water per minute at 160 lb. per sq. in., and the machine can project forward a heavy screen of water-fog and/or carbon dioxide through nozzles housed below the front bumper. This frontal screen can be controlled and directed from the driver's cab. At the same time, firemen on the appliance can bring other equipment into use. A foam monitor is mounted on the roof, and can also be operated from within the cab, only the head and shoulders of the operator projecting above the roof. Two roof-mounted fog nozzles are also fitted, while in addition there are two foam lines and a high-pressure fog line. Carbon dioxide equipment includes four 40 lb. gas cylinders, two on each side of the vehicle. Also included is a 250 gallon water tank and a foam compound tank. A 25 ft. light-alloy ladder is carried.

The Merryweather tender can throw forward a protective screen which enables it to approach close to aircraft fires.

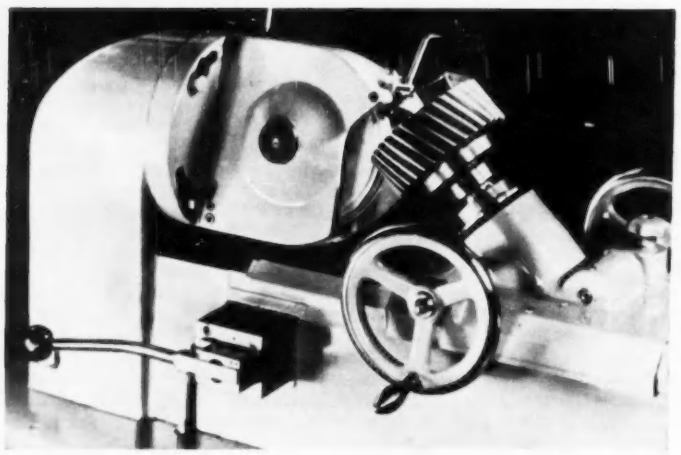
DE-BURRING GEAR TEETH

Designed for de-burring spur helical and bevel gears, the machine illustrated below is made by Gerb. Boehringer G.m.b.H., Goeppingen-Wurtt., the agents in this country being the Sykes Machine Tool Company, Limited, Staines, Middlesex. The machine can accommodate spur and helical gears from 5 to 51 D.P., and helical gears with a maximum helix angle of 25 deg. The maximum pitch circle diameter is 15¾ in.

De-burring is by means of a grinding wheel 8 in. in diameter, mounted on a true-running arbor by means of a locating flange. The grinding wheel periphery has a worm profile corresponding to the tooth form and pitch of the gear to be de-burred, and a separate wheel is used for each pitch. The wheel head is easily adjustable up to an angle of 25 deg. on each side of the centre-line in order to match the angles of helical gears.

The gear being de-burred is free to rotate on its mounting arbor, and is rotated by means of the lead on the grinding wheel profile. The gear and grinding wheel engage so that their axes are at 45 deg. when viewed from directly above the face of the work, and as both revolve in mesh, the tips, flanks and roots of all teeth are uniformly de-burred. Wear on the grinding wheel is very small; dressing, which can be carried out with a carbide-tipped tool in a centre lathe, is only necessary at infrequent intervals. The wheel can be used down to approximately 5½ in. diameter. A 1 h.p. motor drives the grinding wheel, which runs at 2,800 r.p.m., while a separate motor of 1/3 h.p., running at 11,000 r.p.m., drives a dust-extractor, the dust being removed in a fluid centrifugal separator.

High operating speeds are possible with this machine, typical figures being: spur gear 4 in. diameter, 16 D.P., 0·36 minute for complete deburring; helical gear, 1¼ in. diameter, 6 D.P., 20 deg. helix angle, 0·38 minute.



The Boehringer gear tooth de-burring machine uses a grinding wheel with a worm profile which turns the freely-mounted work-piece.

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INFLATABLE LIFE-RAFTS DRIFTING AT SEA

Interesting facts about the behaviour of inflatable life-rafts were revealed when the Seine-net fishing vessel "Jane Jorgensen" foundered in the North Sea on September 30, 1956. The crew of four boarded the six-person inflatable life-raft with which the ship was equipped and were picked up by the German m.v. "Ursula Schulte" 15 hours later. The raft was then abandoned and was not sighted until nearly five days later.

During the whole of this period the raft appears to have drifted comparatively slowly. While it was still carrying the survivors, the wind and sea were south-westerly: wind force was 4 to 6 and wave heights 8 to 10 ft. with a period of 5 to 7 seconds. During these 15 hours the raft drifted 14 to 15 miles. After it was abandoned, it continued to drift at the rate of nearly 18 miles a day. The wind and sea were now predominantly westerly, with wind force 4 to 7 for the most part and wave heights of 6 to 14 ft. The eastward drift may have been assisted by the prevailing surface current, which was probably about 5 to 10 miles a day, so that the actual wind drift was small.

The drogue would seem to have been responsible for reducing the drift so effectively. The survivors stated that the raft rode well and no water entered it; the occupants were warm and comfortable.

This information will be of value to any navigators—by sea or air—who may have occasion to search for an inflatable life-raft in the future. A detailed table giving the rate of drift to be expected of inflatable life-rafts, loaded and unloaded, under all conditions is contained in a search and rescue manual produced by the International Civil Aviation Organization. From the figures in that table behaviour closely similar to that experienced in this case would be expected. Other things being equal, larger rafts will drift faster.

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WINDING HEAVY COILS

A face-plate winder for heavy duty has been produced by Westool Limited, St. Helens Auckland, Co. Durham. It is primarily for winding coils in lifting magnets, transformers, etc. The 30 in. diameter face-plate is slotted to enable coil formers to be clamped to it and is capable of winding coils up to 28 in. in diameter, with a maximum width of 6 in. The range of wires that can be used is from 10 to 30 s.w.g. A four-speed gearbox gives a choice of speeds up to 415 r.p.m. and gear changing is carried out by the rotation of a spider handwheel. A calibrated scale is included for setting the number of turns per layer. The winder has a 2 h.p. induction motor to drive it, with Warner electromagnetic clutches and brakes.

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In the article on "Tools and Jigs Made from Master Moulds," on page 373 of the March 22 issue of ENGINEERING, Fig. 5 should have been described as illustrating an upper fuselage panel of the Vautour aircraft—not a rear fuselage panel of the Mystère IV.

THE PACE GETS HOTTER

Conditions of New Severity for Electronic Components

Study of the stands reveals that many of the firms at the 1957 Radio Components Show have a speculative eye on the development of high temperature operation. True, the idea of what constitutes a high temperature varies. The favourite figure appears to be in the region of 250 deg. C. But the range extends from 80 to 1,600 deg. C. The variety of circumstances in which high temperatures are present probably causes some of the confusion. Class H insulation does operate at a high temperature when conventional insulation is the yardstick. Yet the class H insulation is relatively cool in comparison with the liquid sodium in the Dounreay fast reactor. Fortunately, the mechanical, electrical, and thermal requirements in the two situations are different.

In another field, the problems are more complex. Supersonic aircraft contain a large variety of electrical and electronic equipment and, as flying speeds increase beyond 1,000 m.p.h., temperatures rise steeply. The operation, at elevated temperatures, of complete electronic circuits containing a wide variety of components is extremely difficult. At none of the recent exhibitions has any electronic equipment been displayed capable of operating at the temperatures that can be expected in future aircraft. However, it is probable that much of the information on this subject is of a classified nature and that research and development is being conducted in Government establishments.

Present techniques rely on the use of lead-through insulators, capable of operation at about 500 deg. C., to connect detectors in high temperature regions to equipment that is thermally shielded or refrigerated. Lead-through insulators of this type were displayed by Ferranti Limited, Hollinwood, Lancashire, and have found application at Dounreay. The same firm also exhibited their "Hitemp" transformer. The component, shown in Fig. 1, was designed for power distribution in aircraft and can be operated at 250 deg. C. The design obtains the maximum benefit from heat conduction through the chassis or framework on which the unit is mounted. Nevertheless, the manufacturers claim that the construction enables the transformer to operate satisfactorily when the losses are dissipated by convection and radiation only. The range consists of six single and six three-phase frame sizes utilising "C" or "E" type cores of cold-rolled oriented silicon steel. Insulation resistance between windings is not less than 5,000 megohms at room temperature and better than 50 megohms at 250 deg. C. The terminals are made of heat-resisting copper alloy to eliminate creep and consequent loosening of connections at high temperatures.

An insulated wire capable of operating at about the same temperature was displayed by British Insulated Callender's Cables, Limited, London, W.C.1. Polytetrafluoroethylene (P.T.F.E.) is an insulator that will operate up to 240 deg. C. It is noninflammable and is unaffected by oils, and fuels. When required for operation at 500 volt r.m.s. the insulation thickness is 0·012 in. Thus, the wires are suitable for aircraft use where the space factor is of importance.

The same insulant is used in a new range of capacitors produced by the Telegraph Condenser Company, Limited, North Acton, London, W.3. In the tubular type of construction these capacitors extend up to 0·2 microfarad; above this capacity the unit is housed in a metal box with ceramic bushings. Suitable for working at 200 deg. C., the capacitors are claimed to have an exceptionally high internal resistance and low power factor. The Dubilier Condenser Company (1925), Limited, North Acton, London, W.3, have employed a different dielectric in their high temperature capacitors. The "Terecap" range—examples are shown in Fig. 3—have Terylene for the dielectric and are mounted in metal tubes with ceramic end seals. The range is suitable for temperatures up to 125 deg. C.

Solid-state devices such as rectifiers and transistors do not, as yet, operate at high temperatures.

Fig. 1 Capable of operating at 250 deg. C., the "Hitemp" transformer was designed for power distribution in aircraft.

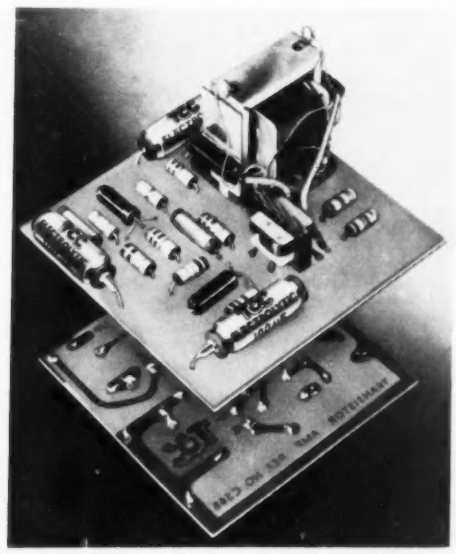

Fig. 2 Views of the upper and lower sides of a printed circuit amplifier using transistors.

Germanium junction transistors have a maximum operating temperature of about 50 deg. C.; some germanium diodes may be operated at up to 75 deg. C. Metal rectifiers of small size and light weight, for high temperature operation, were exhibited by the Westinghouse Brake and Signal Company, Limited, King's Cross, London, N.1. The "Westalite" range is suitable for operation at 85 deg. C. and units are made for various current-carrying capacities between 0·08 and 5 amperes. The solution to the problem of using semiconductors at elevated temperatures seems to lie in the use of silicon instead of germanium. Whereas the energy necessary to transfer an electron from the valence to the conduction band is 0·7 eV in germanium it is 1·1 eV in silicon. Consequently, the latter material does not become an intrinsic semiconductor until it reaches about 170 deg. C.

A range of silicon junction diode was displayed by the General Electric Company, Limited, Kingsway, London, W.C.2. Capable of operation with junction temperatures of 150 deg. C., the diodes are available for a variety of peak inverse voltages. An experimental model, the EW3/2, is capable of withstanding a peak inverse voltage of 400 volts, and passes a forward current of 300 milliamp. The highest frequency of operation is about 2·5 kc/s.

PRINTED CIRCUITS

Equipment for printed circuits was much in evidence at the exhibition. Fig. 2 shows a 200 milliwatt transistor amplifier produced by the Telegraph Condenser Company, Limited. The company produces a range of paper dielectric and electrolytic capacitors—the illustration includes several examples of these—that have been developed for use in such circuits. Among the materials recently developed by Bakelite, Limited, Grosvenor-gardens, London, S.W.1, is a flexible grade of Bakelite copper-clad laminate for use in printed circuits that occupy more than one plane. An application of this grade has been in the Ferranti "Mercury" computer. A wide range of miniature components was displayed by the Plessey Company, Limited, Ilford, Essex. Capacitors, designed for printed circuit panels, in which attention had been paid to the requirements of automatic assembly processes were on show. The tags of the capacitor were mounted in a special moulding that ensured alignment on insertion. The capacitors themselves were mainly of fabricated plate construction but some were of etched foil.

Various printed circuit connectors have been developed by Power Controls, Limited, Newmarket, Suffolk. A spacing of 0·156 in. is used. Care has been taken to ensure that the contacts do not damage the printed-circuit foil.

TRANSISTORS

The increasing application of transistors was apparent at the show. Reproducers and Amplifiers, Limited, Wolverhampton, Staffordshire, displayed a loudspeaker unit with a high impedance centre-tapped coil for direct connection to transistor push-pull output stages in audio amplifiers. A portable public address system containing a 10 watt amplifier and operating from a 12 volt dry accumulator was shown by Lustraphone Limited, Regents Park-road, London, N.W.1. The amplifier is fully

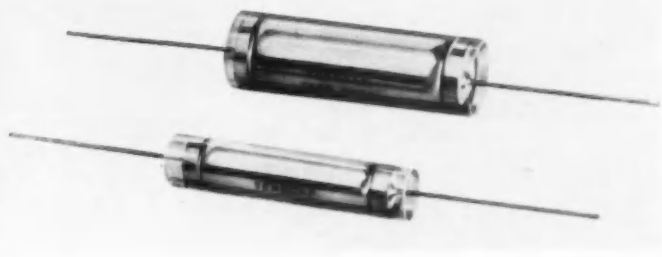

Fig. 3 The use of Terylene as a dielectric enables these capacitors to operate at 125 deg. C.

transistorised and the equipment may be used continuously for 14 hours. The total weight is 24½ lb.

Miniature batteries for use in portable transistorised equipment were a feature of the stand occupied by Mallory Batteries, Limited, Dagenham, Essex. The mercury cell which does not require rest periods is used. Continuity or intermittency of discharge are irrelevant to delivered capacity. The smallest, type RM400, weighs 0·04 oz. and stands 0·125 in. high. Various other types are produced and discharge capacities betwen 0·08 and 3·6 ampere hours are available. Two types of anode are used: a pellet of amalgamated zinc powder of uniform grain size, or a winding of thin corrugated zinc strip. The depolarising cathode is of pure mercuric oxide to which a small amount of micronised graphite is added. The electrolyte is concentrated aqueous solution of potassium hydroxide substantially saturated with zincate. It is claimed that the use of this electrolyte ensures a high degree of stability within the cell and limits the possibility of hydrogen evolution during shelf storage or normal discharge. The nominal voltage of a single cell is 1·34 volts.

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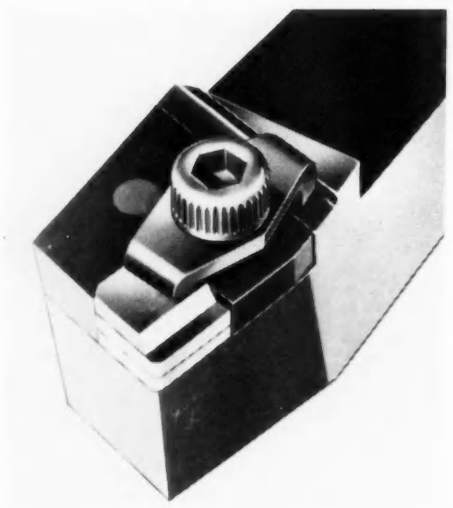
EXPENDABLE TOOL TIPS



Clamped to the tool-holder so that they can be turned to present fresh cutting edges, the new Wimet tool tips are thrown away when all the edges are work-dulled.

A new range of tungsten-carbide tool tips, introduced by Wickman, Limited, Wimet Division, Torrington-avenue, Coventry, is designed on the "throw-away" principle. The tips, which are available in either square or triangular form, are clamped to the tool-holder shank, together with a chip-curler if required, and are turned round or over to present a new cutting edge as soon as the old one is work-dulled. They are not re-ground. As soon as all the eight edges on the square tip or the six edges on the triangular one have been used, the tip is discarded.

The tool-holder is made of toughened carbon steel, with a seating for the tip provided by a dowelled locating piece. The seating gives a 5 deg. negative cutting rake and the normal 5 deg. front to back angle. A socket-head screw and clamp retain the assembly in position. Two tips are accommodated in the seating, the lower one acting as an anvil for the cutting tip, and as a wear-resistant face to prevent abrasion of the shank by swarf. The clamp is reversible, for use either with or without a chip-curler.

The tips are available in two grades of carbide, Wimet grade N for cast iron, and grade XL2 for steel, and in four styles giving approach angles of 15, 30 or 45 deg. with the square tip, and zero deg. with the triangular one.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CANTERBURY
"The History of Lighting," by J. Roper. Kent Branch. County Hotel, Canterbury. Thurs., April 25, 8 p.m.
HOVE
"Practical Applications of Modern Science," by H. E. J. Butler. Brighton, Hove and District Branch. New Imperial Hotel, First-avenue, Hove. Wed., April 24, 7.30 p.m.
OXFORD
"Applications of the Cathode-Ray Tube," by C. H. Gardner. Oxford, Reading and Districts Branch. Regents Park College, Pusey-street, Oxford. Sat., April 27, 6.30 p.m.

British Institute of Management

LONDON
"Appointment of an Employee Director," by E. O. Landau. Reading Room, Polytechnic, Regent-street, W.1. Thurs., April 25, 6.30 p.m. (Meeting place changed.)

British Institution of Radio Engineers

LONDON
"Properties of Semi-Conductor Devices," by Dr. A. A. Shepherd. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 24, 6.30 p.m.*
EDINBURGH
Annual General Meeting at 6.30 p.m. "Special Process Instrumentation in Atomic Energy Projects," by H. Bisby, at 7 p.m. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., April 26.

British Interplanetary Society

LONDON
Films on British and American Rocket Developments. Science Museum Exhibition-road, S.W.7. Sat., May 4, 2.30 p.m. and 6.30 p.m. (Admission by ticket only.)

Building Centre

LONDON
Film on "Hadrian Paint," exhibited by Smith and Walton Ltd. Wed., April 24, 12.45 p.m.

Chemical Society

ST. ANDREWS
"Some Bimolecular Gas Reactions," by A. F. Trotman-Dickenson. St. Andrews and Dundee Branch. Chemistry Department, St. Salvator's College, St. Andrews. Fri., April 26, 5.15 p.m.

Combustion Engineering Association

LONDON
"Selection of Plant for Power and Process Requirements," by R. Nichol. Waldorf Hotel, Aldwych, W.C.2. Wed., April 24, 10.30 a.m.
MANCHESTER
"Comparison of Conventional Space Heating Systems," by J. R. Kell. North Western Section. Engineers' Club, Albert-square, Manchester. Wed., May 1, 10.30 a.m.

Engineers' Guild

EDINBURGH
Annual Genera Meeting. Edinburgh Centre. Scottish Liberal Club, 109 Princes-street, Edinburgh. Mon., April 29, 6.15 p.m.

Helicopter Association of Great Britain

LONDON
"Helicopter Operations at Port Said," by Lieut.-Colonel J. F. T. Scott. 19 Park-lane, W.1. Thurs., April 25, 6.15 p.m.

Illuminating Engineering Society

BATH
Annual General Meeting and Film Evening. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Fri., April 26, 7 p.m.
BIRMINGHAM
"A Feminine Point of View on Domestic Lighting," by Mrs. Kay Hudson. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., April 26, 6 p.m.

Incorporated Plant Engineers

LONDON
"An Engineer Looks Ahead: Modern Trends in Factory Design and Equipment," by E. C. Stevens. Cromwell Hall, Earl's Court, S.W.5. Mon., April 29, 2 p.m.
BIRMINGHAM
"Earthing and Earth Leakage Protection," by J. A. Robbins. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., April 26, 7.30 p.m.
LEEDS
Film Evening, including "Basic Principles of Lubrication." West and East Yorkshire Branch. The University, Leeds. Mon., April 29, 7.30 p.m.
SHEFFIELD
"Welding Applied to Maintenance," by A. O'Donnell. Sheffield Branch. Grand Hotel, Sheffield. Thurs., April 25, 7.30 p.m.
SOUTHAMPTON
"Liquid Petroleum Gases," by C. F. Port. Southern Branch. Polygon Hotel, Southampton. Wed., May 1, 7.30 p.m.

Institute of Fuel

LONDON
Presidential Address. Institution of Civil Engineers, Great George-street, S.W.1. Wed., April 24, 5.30 p.m.*
Annual General Meeting. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., April 25, 5.30 p.m.*

Institute of Marine Engineers

LONDON
Annual General Meeting. Tues., April 30, 5.30 p.m.*
BRISTOL
Film Evening. West of England Section. Grand Hotel, Bristol. Mon., April 29, 7.30 p.m.

Institute of Metals

LONDON
Spring Meeting, Mon., April 29, to Sat., May 4:
May Lecture on "Education in Science and Technology," by Sir Eric Ashby. Royal Institution, Albemarle-street, W.1. Mon., April 29, 6.30 p.m.
Annual General Meeting, and Presidential Address by Dr. L. B. Pfeil, at 9.30 a.m. Discussion on "The Metal Physics of Corrosion and Oxidation," at 2.30 p.m. Church House, Great Smith-street, S.W.1. Tues., April 30.
Scientific Sessions. Church House, Great Smith-street, S.W.1. Wed., May 1, 9.30 a.m. and 2.30 p.m.
Scientific Sessions. 17 Belgrave-square, S.W.1. Thurs., May 2, 10 a.m.

Institute of Petroleum

LONDON
"The Properties and Use of Bitumen in Road Making"; papers by Dr. A. R. Lee and J. H. Nicholas, and P. C. Leaver. Wed., May 1, 5.30 p.m.*

Institute of Physics

ABERYSTWYTH
"Instrumentation of the Liverpool Synchrocyclotron," by Dr. B. Collings. South Wales Branch. University College of Wales, Aberystwyth. Fri., April 26, 5.30 p.m.
BIRMINGHAM
"The Strength of Metals," by Dr. A. H. Cottrell. Midland Branch. Regent House, Birmingham. Thurs., April 25, 7 p.m.

Institute of Refrigeration

LONDON
"The Detection of Refrigerant Leaks," by A. C. Murdock. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., May 2, 5.30 p.m.*

Institute of Road Transport Engineers

MANCHESTER
Annual General Meeting. East Regional Centre. Houldsworth Hall, 90 Deansgate, Mancester. Tues., April 23, 7.30 p.m.
NOTTINGHAM
Annual General Meeting. East Midlands Centre. Mechanics' Institute, Nottingham. Tues., April 30, 7.30 p.m.

Institution of Chemical Engineers

LONDON
Annual General Meeting. Presidential Address on "Petroleum and the Chemical Engineer," by John A. Oriel. May Fair Hotel, Berkeley-street, W.1. Tues., April 30, 11 a.m. (Followed by the annual dinner at 7 for 7.30 p.m.)

Institution of Civil Engineers

LONDON
"Water Supply for Doha, Qatar," by Charles Hogg and G. M. Swan. Public Health Division. Tues., May 7, 5.30 p.m.*
GLASGOW
Annual General Meeting. Glasgow and West of Scotland Association. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Fri., April 26, 7.15 p.m.
NOTTINGHAM
Annual General Meeting. "Some Uses and Advantages of Computing Machines in the Solution of Engineering Problems," by A. C. Stewart. East Midlands Association. Mechanics' Institute, Trinity-square, Nottingham. Mon., April 29, 6.15 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Biritsh Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. ABBey 7315.)
Helicopter Association of Great Britain, 4 The Sanctuary, London S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Plastics Institute, 6 Mandeville-place, London, W.1.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1.
Royal Statistical Society 21 Bentinck-street, London, W.1. (WELbeck 7638.)

SHEFFIELD
Annual General Meeting. "Skidding Resistance of Roads and the Requirements of Modern Traffic," by C. G. Giles. Yorkshire Association. Grand Hotel, Sheffield. Fri., April 26, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"The 138 kV Submarine Power Cable Interconnecting the Mainland of British Columbia to Vancouver Island," by Dr. T. Ingledow, R. M. Fairfield and others. Thurs., April 25, 5.30 p.m.*
Informal Evening. Talks on "Radio in Air-Sea Rescue," introduced by G. W. Hosie, D. Kerr and W. Kiryluk. Radio and Telecommunication Section. Mon., April 29, 5.30 p.m.* Discussion on "The Co-ordination of Education and Practical Training in Sandwich Courses," opened by C. Grad and A. Draper. Education Discussion Circle. Mon., May 6, 6 p.m.* "Invention and Nature," by F. W. Meredith. Measurement and Control Section. Tues., May 7, 5.30 p.m.*

Institution of Heating and Ventilating Engineers

GLASGOW
Annual General Meeting. "Air Conditioning in the British Isles," by J. C. Knight. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., April 30, 7 p.m.

Institution of Locomotive Engineers

LONDON
"Painting and Cleaning of Rolling Stock," by F. Fancutt. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., April 24, 5.30 p.m.*
LEEDS
Annual General Meeting. "Modern Methods of Train Performance Calculation," by S. D. Van Dorp. North Eastern Centre. Great Northern Hotel, Leeds. Thurs., April 25, 6.45 p.m.
MANCHESTER
"Experiences with Diesel Railcars," by M. J. Devereux. Manchester Centre. College of Technology, Manchester. Wed., April 24, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Annual General Meeting. Fri., April 26, 6 p.m.*
"Influence of Dynamical Imperfection on the Vibration of Rotating Discs," by Dr. S. A. Tobias and Dr. R. N. Arnold; and "Free Undamped Non-Linear Vibrations of Imperfect Circular Discs," by Dr. S. A. Tobias. Meeting in conjunction with the Applied Mechanics Group. Fri., May 3, 6 p.m.*
BRISTOL
"Sales and Service in the Transport Industry," by J. M. Forbes. Western A.D. Centre. Royal Hotel, Bristol. Thurs., April 25, 6.45 p.m.
CARDIFF
Selected Graduate Papers. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., April 30, 6 p.m.
NEWCASTLE-UPON-TYNE
Thomas Hawksley Lecture on "Some Engineering Problems in the Industrial Development of Nuclear Power," by Sir Claude D. Gibb. North Eastern Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., April 29, 6 p.m.

Institution of Mining and Metallurgy

LONDON
"Trace Elements in Sphalerite, Galena and Associated Minerals from the British Isles," by E. M. El Shazly, J. S. Webb and D. Williams; and "Stratigraphical and Structural Ore Controls on the Slitt Vein at Heights Mine, Weardale, Co. Durham," by R. J. P. Lyon and B. Scott. Geological Society, Burlington House, Piccadilly, W.1. Thurs., April 25, 5 p.m.*

Institution of Production Engineers

LONDON
"The Development and Application of Hard Metals," by R. N. Cooke. London Graduate Section. Tues., April 30, 7.15 p.m.
MANCHESTER
"Human Relations in Industry," by J. H. Brebner. North Western Region. College of Science and Technology, Manchester. Mon., April 29, 6.30 p.m.

Institution of Railway Signal Engineers

BRISTOL
"Axle Counters," by H. A. Cod. Bristol Branch. Meeting Room above Main Booking Hall, Temple Meads Station, Bristol. Fri., April 26, 5.30 p.m.*

Institution of the Rubber Industry

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., April 25, 6.45 p.m.
LIVERPOOL
Annual General Meeting. Merseyside Section. Stork Hotel, Liverpool. Fri., April 26, 6.15 p.m.

Institution of Structural Engineers

BIRMINGHAM
Annual General Meeting. Films on Prestressed Concrete. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., April 26, 6 p.m.
CARDIFF
"Wind Stresses on Buildings," by H. Ferrington. South Wales Institute of Engineers, Park-place, Cardiff. Tues., April 30, 6.30 p.m.

Junior Institution of Engineers

MANCHESTER
Repetition of Presidential Address on "Fuel Economy and Heat-Electric Generation," by Bryan Donkin. North Western Section. Engineers' Club, Albert-square, Manchester. Tues., April 30, 7.30 p.m.
SHEFFIELD
Repetition of Presidential Address on "Fuel Economy and Heat-Electric Generation," by Bryan Donkin. Sheffield Section. Royal Victoria Hotel, Sheffield. Mon., April 29, 7.30 p.m.

Plastics Institute

LONDON
"Thermoplastics in the Submarine-Cable Industry," by Sir John Dean. Institution of Electrical Engineers, Victoria-embankment, Savoy-place, W.C.2. Tues., April 30, 6.30 p.m.

Royal Aeronautical Society

LONDON
"The Purpose and Problems of Research Aircraft," by F. P. Youens. Tues., April 30, 7 p.m.

Royal Statistical Society

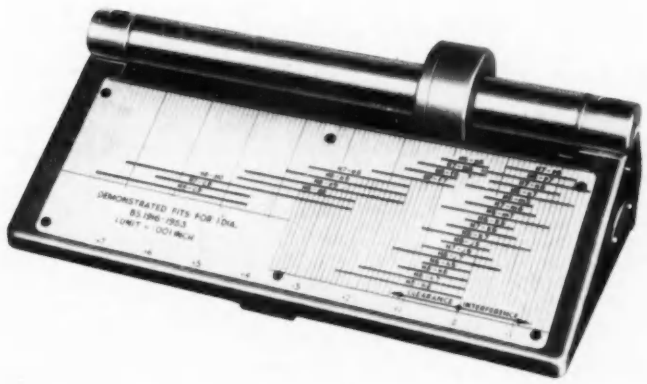
GLASGOW
Annual General Meeting. Discussion on "Electronic Computers." Glasgow Industrial Applications Group. 39 Elmbank-crescent, Glasgow, C.2. Thurs., April 25, 7.30 p.m.
SHEFFIELD
"Machine Translation and Other Uses of Electronic Computers," by Dr. A. D. Booth. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., April 25, 7 p.m.

GETTING THE "FEEL" OF LIMITS AND FITS

Tolerances for fits between shafts and holes, formerly the responsibility of the individual designer, are now generally taken from established standards. This practice has simplified matters considerably, but it is still easy for a designer to specify a closer, and therefore a more costly, fit than circumstances warrant. Degrees of fit cannot be seen, but they can be felt, and to provide a means of comparison which will be readily available in the drawing office or lecture room, the Coventry Gauge and Tool Company, Limited, P.O. Box 39, Fletchamstead Highway, Coventry, have introduced the demonstration unit illustrated below.

It consists of a tapered bar nominally 1 in. diameter, with a sliding datum ring having a bore of the same taper, thus providing parallel clearance between the ring and the bar. Both components are hard chromium plated as a protection against wear. A scale plate mounted in front of the bar and protected by a Perspex cover, is divided vertically to represent specified clearances, and horizontally to represent the minimum and maximum clearance for a number of preferred fits in the diameter range.

The scale is easily detachable, and a choice of scales is available to suit B.S. 1916, ISA, or American/Canadian standard fits. Any scale can be used without modification to the unit, and if a user has a private series of fits, he can prepare his own scale for the unit. It will be seen from the illustration, which shows a unit with a B.S. scale, that several of the horizontal lines denoting fits cross the zero line into the interference zone. Interference cannot actually be demonstrated on the unit, but the scale is arranged to show the extent to which transition fits may extend to the interference zone.



Limits and fits to any chosen standard can be demonstrated by "feel" on this unit.

SPEEDY WALL CHART

A new development in wall charts has been introduced by Adapta-Charts Limited, 129 Hammersmith-road, London, W.14. It is particularly intended for time/load systems, and for this purpose is designed for rapid and easy alteration. The system allows an entire line of "signals" to be removed and replaced in a matter of seconds. The basis depends on a small plastics "signal," of rectangular shape, measuring $\frac{1}{2}$ in. by $\frac{1}{4}$ in. These signals interlock to form a continuous line which can be moved as a group. They are available in several colours for different operations. Each signal has a small plug on its reverse side which fits into an extruded channel screwed to the face of a standard Moviegraph panel. The channels can be fitted so that spare lines of perforations are visible between each to allow standard Moviegraph signals to be inserted.

★ ★ ★

ELECTRICAL LUBRICANT

A lubricant for electrical equipment and for instruments has been developed by Electrolube Limited, Oxford-avenue, Slough, Buckinghamshire. Considerable claims have been made for this fluid, which has been subjected to a certain number of tests in low-voltage electrical installations. One of its main features is that, compared to mineral oils, the electrical resistance is very low. A figure of 2×10^3 megohms for one centimetre cube is quoted for Electrolube, as compared with $1{,}000 \times 10^3$ megohms for mineral oil SAE5. The fluid contains a volatile fraction which acts as a carrier and spreader, and subsequently evaporates without affecting the properties. One effect of the carrier is that it has a loosening action on the tarnish on contacts and the lubricant can thereby improve conduction across contacting surfaces. It is inert to most plastics, water repellent, and has good adhesion to the surfaces concerned. It also exercises a certain degree of spark suppression. The fluid has a flash-point of 470 deg. F. and a pour point lower than — 60 deg. F. At present it is available in gelatine capsules containing approximately 3 ccs.

★ ★ ★

AUTOMATIC CONTROL
Q.M.C. Course in September

An introduction to the theory of automatic control is being offered by Queen Mary College (University of London, Mile End-road, E.1). Of 10 days' duration, the course starts on September 16 and will comprise lectures, demonstrations, and laboratory work. The course is designed to fill the gap in the knowledge of recently qualified graduates who are engaged in the field of control and instrumentation. The course will be from 9.30 a.m. to 5.30 p.m. daily. Arrangements will be made for private study outside these times.

★ ★ ★

A 65 TON CAST OF TITANIUM-BEARING STAINLESS STEEL

On March 28 an exceptionally large cast of 65 tons of titanium-bearing stainless steel was successfully poured from the large arc furnace in the melting shop of Samuel Fox and Company, Limited, Stocksbridge, a subsidiary concern of the United Steel Companies, Limited, Sheffield.

Titanium-bearing stainless steel is a difficult type of material to produce in an arc furnace to very low-carbon specifications and it necessitates careful advance planning, close timing and accurate temperature control.

After rolling into sheet and strip form, the steel will be supplied to makers of atomic-energy and chemical plant where its excellent welding properties are in demand.

ATOMIC REVIEW

Moment of Doubt

ALTHOUGH power from nuclear sources is still rather more expensive than from conventional steam stations—and very much more so than water power—publicity has made nuclear power acceptable (or, at least, accepted) by politicians and their public nearly everywhere. Citizens in many countries are being heavily taxed to meet prodigious expenditure on research projects and power schemes.

Not only in Britain have plans been announced for a large expansion of the nuclear power programme. On the continent of Europe the six Messina countries have ratified their Euratom treaty and several other countries, notably in Scandinavia, have limited projects in hand. Russia has had a nuclear power station working since 1954, and doubtless has several more on the books. Japan, India and the South American states have all gone as far as they dare to make sure they don't get left behind in the race. The United States has spent most and learnt most about numerous reactor systems but has still to find a reactor that will allow power to be generated on a large-scale cheaper than her existing steam stations. Caught in a cleft stick of international propaganda the United States couldn't quite decide whether to join the van of countries with nuclear power stations—as her expenditure so justly deserved—or stand aside until she did find something which is economically sound. Britain's and Europe's advances into the nuclear power age have been forced on them simply because they could not afford to wait for something better to turn up. Even as a by-product of erstwhile defence measures, such power projects have so far been extremely expensive measures.

Broadly speaking the cost to the British taxpayer of installing the 6,000 MW of nuclear power stations is going to be just about double the cost of conventional stations of the same gross capacity. But this large premium must be met because a full year's operation of the first batch of nuclear stations—say in 1966—is going to save 18 millions tons of coal, and the price of coal is growing fast. On the continent much the same argument holds good; coal is not getting any easier or cheaper to get and Euratom's goal is 15,000 MW of installed capacity by 1967. Africa, even taking into account all the announced plans for industrialisation, has no need of nuclear energy at to-day's prices for she is more blessed with latent water power than anywhere else, and water power is really cheap.

Despite the present greater cost of nuclear power—and in spite of the fearful consequences some have prophesied concerning radiation—it does offer a better prospect than the fossil fuels. Research can and will reduce the cost and eliminate the more harmful effects; it may take time but both can be accomplished. True as it may be that the coal and oil resources of the world are sufficient for 1,000 years, they are by no means to be found where they are most likely to be required and their transport takes both time, effort and money. The satisfactory development of nuclear power will do away with the useless effort involved in moving fuels in bulk. Nuclear power is desirable, but only research on a scale never before envisaged can bring home the latent possibilities.

What then are the organisations which have been set up to establish international co-operation on nuclear energy?

Apart from the national authorities of each of the individual countries, three principal international organisations have been proposed, namely: the International Atomic Energy Agency, sponsored by the United Nations Organisation but which has yet to come into actual being; secondly, the Organisation for European Economic Organisation sponsers a special committee for nuclear energy; and, thirdly, Euratom, the body recently set up by the six Messina countries—France, Germany, Italy, Belgium, the Netherlands and Luxembourg—who comprise the European Iron and Steel Community. In addition to these three organisations, of which further details are given below, there are some more specialised bodies such as CERN (European Council for Nuclear Research) and the European Atomic Energy Society. The first of these is an active research unit; the second, to which the United Kingdom and the Euratom countries belong, meets once a year to consider the report of a working party and so acts as a clearing house for nuclear information. A previous survey of these organisations and those referred to below appeared in ENGINEERING, page 397, May 25, 1956.

I.A.E.A.

The statute for the International Atomic Energy Agency was published at the New York headquarters of the United Nations last October. At the time of writing it has as yet to be formally ratified by, among others, the United Kingdom, though the draft statute had originally had the approval of Britain, the United States and the Soviets as well as nine other members of the drafting committee. The broad objects of the Agency will be to further the peaceful uses of atomic energy throughout the world by encouraging research and development; by acting as an intermediary for the supply of materials, equipment and services by one member to another; by itself making provision for such materials and services and acquiring plant and facilities where necessary; by fostering the exchange of scientists and information; by formulating standards of health and safety; and by establishing safeguards designed to ensure that materials, equipment, services and information made available under agency arrangements shall not be used for military purposes. These controls are to be administered through an international inspectorate with the right to enter the territories of any member state. Inspectors will have access at all times to places, persons and data concerned with fissile material so that regulations regarding its use and the statutory safety precautions may be enforced. Punitive clauses include the suspending of assistance to or membership of states not complying with the provisions of the statute.

When the statute came to be published it promptly ran into trouble. The Soviets put forward a three-part amendment to the proposed financial structure of the Agency. They suggested that there should be only voluntary contributions for erecting its facilities, rather than that the costs should be apportioned among the constituent members; the various clauses permitting the borrowing of money were inverted so denying any power to borrow; and required that any financial decisions made by the governors be made by a three-quarters instead of a two-thirds majority. These political manoeuvrings were countered by the British delegates who said that if the agency were compelled to rely wholly on voluntary contributions it would never be in a position to plan its real work.

Finally, however, the statute was accepted without amendment and 80 odd countries have signed it. Formal, but essential, ratification by the governments of the 18 principal states involved is still to come but is expected within a matter of weeks. In March a committee of the preparatory commission met to plan recommendations to be discussed at the first meeting of the Agency which, subject to the ratifications being forthcoming, will be held in Vienna, probably in early autumn. It is then likely that Vienna will be confirmed as the Agency's permanent headquarters and that subsequent meetings will be held annually.

Having agreed the projects to be undertaken, the Agency will then provide the materials, services, equipment necessary for peaceful research. In this connection the United States Government has pledged 5,000 kg. of fissionable uranium for the Agency's use. This, and other contributions, will become the property of the Agency itself and will not pass into ownership of the members chosen to undertake the actual work. Special efforts are likely to be made with respect to training scientists and in establishing research on radiation problems.

Euratom

Euratom came into being last month with the objective—by co-operation between the six countries concerned—of catching up on the lead held by the United States and the United Kingdom in nuclear power experience and of establishing 15,000 MW of nuclear capacity by 1967 in order to reduce the dependence on fossil fuels. In broad principle both the United States and the United Kingdom have promised their help and teams of experts from both countries have already gone on to the continent to study the problems locally. Indeed, it still is the hope of the " little Europe " countries that the United Kingdom can be persuaded to join them.

Before the ratification Euratom sent its " three wise men " on a hurried tour of the United States and the United Kingdom and conversations were held with both governments and with the leading construction consortia in both countries. Generally speaking, however, Euratom's problems are more akin to Britain's than to America's, and her plans to go ahead now are likely to be very similar to Britain's : power stations based on the gas-cooled reactor using natural uranium or, at best, only slightly enriched uranium.

Euratom's authority over the area's development will be achieved by retaining a tight hold on the relevant materials available: it will have almost monopoly rights over all radioactive materials, natural nuclear fuels or prepared materials that may be imported or produced within the area. Military projects remain purely a national responsibility but the treaty requires full inspection and interchange of information, though the fissile material involved remains the sole possession of the individual country. The close association with the coal and steel community will ensure that material of construction is also evenly distributed according to the overall plan for Euratom. Subject to the overall plan, national development will be permitted, though it is to be expected that many common installations will be built in which countries outside the six may well participate. Problems of siting the nuclear stations may well prove to be the point of issue in this respect for all six countries are densely populated and, apart from transmission costs, there are some desirable features about northern Europe's coastline.

More important immediately than actual stations is the need for a common research plan and training facilities, and to this end the member countries have put up £77 million to be spent during the next five years. The results of research in one country are to be shared with all and information acquired through external agreements with other countries are to be similarly pooled. It has been reported that a common research centre is to be established where five or so experimental reactors will be installed and that a university department specialising in nuclear physics will be brought into being. A uranium 235 separation plant and a breeder station are likely to be among the initial " working " projects.

O.E.E.C. Plans

The plans for nuclear power sponsored by the Organisation for European Economic Co-operation are more broadly based than those of Euratom. In addition to the six Messina countries, the United Kingdom subscribes as do Austria, Denmark, Norway, Portugal, Sweden, Switzerland and Turkey. A steering committee was first set up last summer with two

principal tasks: drawing up terms of reference for two study groups, one to consider a joint plant for the processing of irradiated materials, the other to prepare a draft statute for a security control organisation which would ensure that joint undertakings would not be used for military purposes. It is the contention of O.E.E.C. that their plans in no way conflict with those of Euratom. In particular, overlapping or duplication should be prevented since the principal delegates to Euratom will also represent their countries at O.E.E.C. meetings.

O.E.E.C. sees its role as a means of associating the nations interested in nuclear power which are not members of Euratom with Euratom itself and with projects which Euratom does not wish to undertake. It can also, of course, permit Euratom nations to participate in projects which Euratom itself does not wish to undertake. It will avoid the necessity for a lot of bilateral agreements. In this connection, its chief role will, obviously, be to act as a point of contact between Britain and Euratom. Sweden, where nuclear work and resources are also advanced, is another major case in point. Both Britain and Sweden, and Switzerland, where there is a reservoir of capital, a technically advanced industry, and a strong interest in nuclear energy due to the country's poverty in natural resources, are members of O.E.E.C., though not of Euratom.

Plans for working are now nearing completion, including it is believed the choice of sites, and the Council is expected to give the go-ahead on at least the principal projects during this coming summer. The first of these is the chemical processing plant for irradiated fuel, already mentioned; it is proposed that this plant should be brought into commission during 1960 and be capable of dealing with about 50 tons of natural or slightly enriched uranium a year. It would also serve as a pilot plant for a much larger one planned to come into operation in 1964-65, as the main power station programme begins to show results. Although no statement has been made on its location, the committee are in favour of the plant being owned and administered by an international company in which both public and private money is invested.

A provisional announcement has also been made about an £11 million programme for experimental reactors; Britain, France and Germany have all put forward claims for housing one or more of these reactors. One is to be a fast breeder; one fuelled by either liquid uranium or thorium metal; one will be for testing materials; one of the homogeneous aqueous type in which a uranium salt is dissolved in water; and the fifth will be a prototype boiling-water reactor. Studies have also been put in hand for examining a continental-wide plan for power stations, but the result of a preliminary examination of possible reactor types is awaited before much consideration will be given to a power programme.

More recently it has been announced that work will be concentrated in the first instance on three of the above five reactors, namely: the homogeneous aqueous reactor, the materials-testing reactor and the fast breeder.

Limitations

In contrast to the organisations that have been put into being to bring about co-operation there are the censorships imposed by the individual nations. Nuclear engineering may have had its beginnings in pure science, in a fundamental desire to obtain knowledge about matter, but it passed through that period when its sole overwhelming significance was its use towards fashioning weapons of war. To some considerable extent that motive remains—atomic power as an instrument of war. Knowledge within the field and in related areas all has a military significance and—unfortunately—it can be well argued that it would be regrettable if that knowledge were freely dispensed. On a lower plane, the same knowledge now also has a commercial value.

Each of the organisations previously described has a statute containing clauses which specifically demand the interchange of information among member countries. And those clauses also relate implicitly to information obtained under a bilateral agreement with a non-member. The consequences are immensely involved: defence measures are a prerequisite of continued autonomous existence of the nations; but research benefits only from discussion and exchange. The difficulties of drawing the line of declassification are imponderable. How much so is the subject of the postscript to this week's Atomic Review.

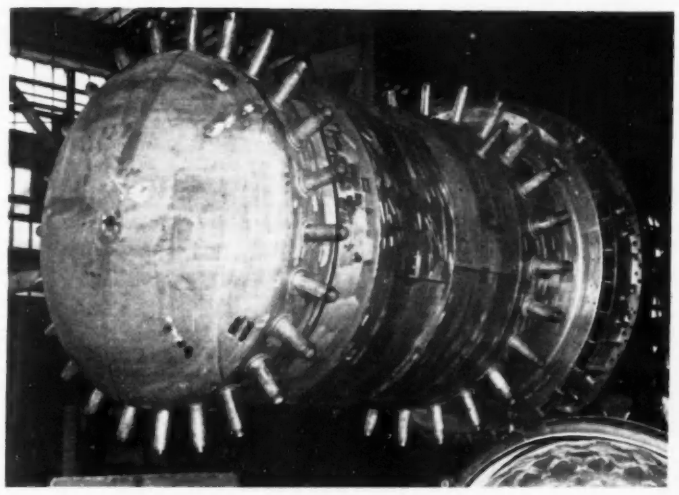


Fig. 1 (left) The stainless-steel pressure vessel built by John Thompson Limited for the fast breeder reactor at Dounreay is about 20 ft. long and 14 ft. in diameter. It contains control-rod and instrument tubes, rotating shields and other components located to within a few thousandths of an inch.

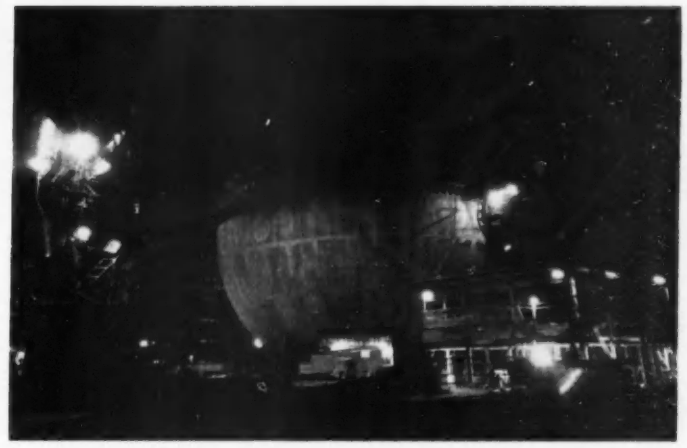


Fig. 2 (right) Night view of construction work on the Dounreay reactor containment sphere (centre), the control room building (left) and the secondary heat exchanger and turbine house (right).

Dounreay Fast Breeder

Reactor Vessel

What is thought to be the most complicated stainless-steel vessel ever fabricated is the 30 ton stainless steel container for Britain's first full-scale fast breeder reactor at Dounreay, on the north coast of Scotland. It has been made for the United Kingdom Atomic Energy Authority, together with liquid-metal heat-exchange systems and boiler plant, by John Thompson, Limited, and is shown in Fig. 1. The vessel has taken 18 months to build, and its overall dimensions are some 20 ft. by 14 ft. The complex control-rod tubes, instrument pipes, rotating shields and inner components of the vessel have been located and welded to within a few thousandths of an inch. More than 3,500 X-ray negatives have been taken to ensure that every welded joint is absolutely leak-proof. For safe transportation the vessel is being carried in a specially fabricated steel cradle which has previously been tested by using a steel and concrete mock-up of the same general dimensions, weight and centre of gravity as the vessel itself. On site at Dounreay, the reactor vessel will be placed in position in the vast concrete valt, some 6 ft. thick, which acts as a biological shield for the reactor and all the primary liquid-metal circuits taking heat from the reactor. This vault is, in turn, enclosed within the huge steel sphere 135 ft. in diameter; a nocturnal view appears in Fig. 2, while Fig. 3 shows the reactor vault. For many months John Thompson construction men have been at work within the vault, assembling and welding the complicated and close-packed stainless-steel circuits which will be connected to the reactor vessel when it is placed in position. A part of the heat-exchanger tubing was shown in position in an illustration in Atomic Review on March 29.

Ventilation and Insulation

In the Dounreay fast breeder reactor, insulation and ventilation present a number of special problems and these have been tackled by Henry Hargreaves and Sons, Ltd., who have also been associated with similar work at Calder Hall, Capenhurst, Springfields and Windscale. The work falls primarily into two fields—metal-clad insulation in the vault housing the reactor and the ventilation of laboratories and ancillary buildings.

All internal surfaces of the vault have been covered with metal-clad insulation panels. The panels form part of the cooling system on all internal vault surfaces, protecting the concrete shielding and roof columns from the effects of the high operating temperature inside the vault. Each of the 1,200 panels was constructed from mild-steel sheets and plates packed with mineral wool. Each panel was designed to accommodate over 500 perforations formed to suit the labyrinth of pipes, plant and equipment housed in the vault. With this large number of fixed location points a very high degree of accuracy in construction and erection was required, and to ensure this, sections of panels were pre-assembled at the Hargreaves works in Cook-street, Bury, Lancashire. The insulation was fitted, clamped and sealed in position on a system of mild-steel support channels and stools arranged so as to allow free and even air flow over all concrete and roof support column surfaces, with a two-pass system serving the roof. The cooling air is introduced in a closed circuit at floor level in the vault and is forced over wall and roof surfaces before extraction at roof level for cooling and re-circulation. A drawing of the vault showing the cleading is reproduced in Fig. 3, and Fig. 4 is a view looking down on the upper surface of the vault.

The filtered warm air supply and active air

extraction systems serving the main chemical plant buildings consist of ductwork systems constructed from galvanised and stainless steel. The main supply and extract ducts convey fresh air to "clean" areas and exhaust foul air from "dirty" areas. The air movement in the buildings is induced from a main extract plant remote from the laboratories and connected to each building by underground concrete ducts. The construction of the buildings is such that negative pressure created by extractor fans induces the fresh air supply through the duct system and filtration plant. In each of the laboratories a system of stainless-steel extract ductwork serves the cubicles and glove boxes. This part of the work is of welded construction; the joints are welded *in situ* and subjected to a test pressure of 5 lb. per sq. in.

General Notes

C.E.A. Expenditure on Nuclear Stations

In the recent White Paper, *Capital Investment in the Coal, Gas and Electricity Industries*, it is stated that an expenditure of £233 million has been approved for the Central Electricity Authority for the period 1957-58 (the total for the three industries is £440 million). It appears that a major revision of the original plans of electricity boards in England and Wales has been called for by the modified nuclear programme (see Atomic Review, March 15). The main increase due to the substitution of nuclear for conventional stations does not come into effect until the 1960s, but in the period up to 1965 the additional cost of the nuclear power programme is estimated to be some £750 million above the expenditure (estimated at £2,600 million) which would have been necessary had only conventional stations been involved. Thus between 1957-58 and 1960-61 the total capital expenditure of the C.E.A. and the South of Scotland Electricity Board is calculated to average £280 million a year, whereas a comparable programme of conventional stations would require some £250 million. Corresponding figures between 1961-62 and 1965-66 would be £400 million and £270 million a year. (6,000 MW of nuclear capacity are planned by the end of 1965.) In the period 1957-58 the approved expenditure for the C.E.A. on nuclear power stations is £12 million as against only £3 million for 1956-57.

Seeking Information

At a recent meeting of Aslib (formerly the Association of Special Libraries and Information Bureaux), Mr. R. M. Fishenden, head of the scientific administration office in the Atomic Energy Authority, discussed the means by which information on atomic energy subjects could be located. In particular he referred to the distribution of unclassified (non-secret) reports and other sources made available by the Authority; these details are summarised in the table below. Atomic energy documents are deposited in the following libraries: Science Museum Library, London, S.W.7; Central Library, High-street, Acton, W.3; Department of Industrial and Forensic Science, Verner-street, Belfast; Central Library, College-green, Bristol, 1; The Mitchell Library, North-street, Glasgow, C.3; Central Public Library, Albion-street, Kingston-upon-Hull; Central Library, Calverley-street, Leeds, 1; Central Library, William Brown-street, Liverpool, 3; Central Library, St. Peter's-square, Manchester, 2; Central Library, New Bridge-street, Newcastle-upon-Tyne, 1; and Central Library, Surrey-street, Sheffield, 1.

TABLE LOCATION OF UNCLASSIFIED U.K.A.E.A. REPORTS AND OTHER SOURCES

Period Covered	Issuing U.K.A.E.A. Group	Papers Published In	Reports for Sale	Reports not for Sale
June, 1946, to June, 1951 ..	Research Group	The official publication "Harwell"	A.E.R.E. INF/BIB96	—
June, 1951, to August, 1954 ..	Research Group	A.E.R.E. INF/BIB96	A.E.R.E. INF/BIB96	A.E.R.E. INF/BIB110
August, 1954, to December, 1955	Research Group	A.E.R.E. INF/BIB96 Supplement 1	A.E.R.E. INF/BIB96 Supplement 1	A.E.R.E. INF/BIB110
December, 1955, onwards ..	All Groups	U.K.A.E.A. List	U.K.A.E.A. List	U.K.A.E.A. List

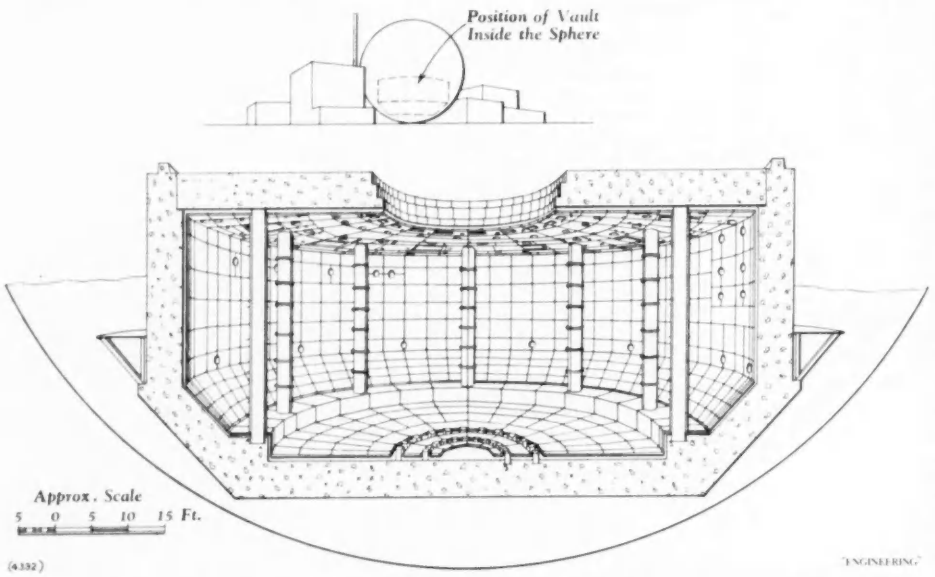


Fig. 3 Vault of the Dounreay fast breeder reactor showing cleading. Henry Hargreaves and Sons, Limited, have been responsible for insulation and ventilation work.

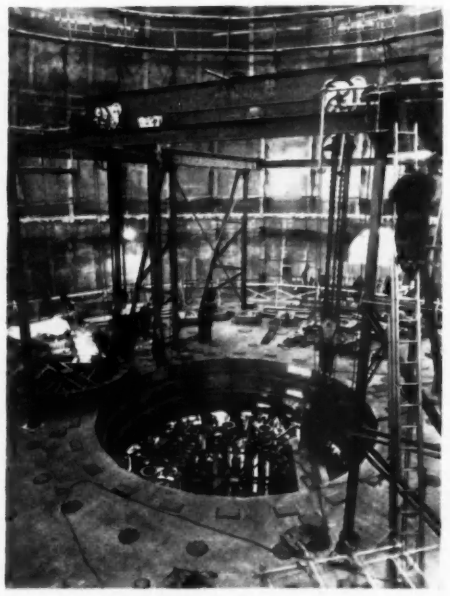


Fig. 4 Inside the containment sphere of the Dounreay reactor, showing the top of the reactor vault, part of the core supporting structure, the 24 heat exchanger banks and the 24 electromagnetic pump units.

Dust Extraction

A two-stage dust collector designed for the elimination of dust particles in the closed carbon dioxide circuit of gas-cooled reactors and said to require no maintenance is made by Mancuna Engineering Limited, of Denton, Manchester. The Mancuna-Dustex D.450-2, for example, is stated to be capable of handling 20 lb. of carbon dioxide per second at 180 to 200 deg. C. and 140 to 160 lb. per sq. in., and to remove 90 per cent. of the entrained dust particles. The pressure vessel is 2 ft. 8 in. in diameter and the overall height is 8 ft. 3 in. The plant operates over the designed range up to full load at a constant pressure/volume ratio.

Safety Exhibition

The S.A.F.E. (Safety and Factory Efficiency) Exhibition held in Birmingham every second year will devote considerable attention this year to atomic energy. A major exhibit will be provided by the Atomic Energy Authority and will include a working model of the Calder Hall station together with displays showing the use of radioactive isotopes. A section on health and safety will show the measures taken by the Authority to protect its staff (now numbering over 24,000) and the general public. In conjunction with the exhibition a congress is to be held at which prominent members of the Authority will speak. The following subjects will be covered: "Training for Atomics" (Mr. Ivor Hopkins, Chief Training Officer of the Industrial Group); "Isotopes in Industry" (Dr. H. Seligman, Head of Isotope Division, A.E.R.E., Harwell); "Health and Safety when Using Radioactive Materials" (Dr. A. S. McLean, Chief Medical Officer, Industrial Group); and "Atomic Reactors" (Dr. J. V. Dunworth, Head of Reactor Division, A.E.R.E., Harwell). Four films ("Opening of Calder Hall," "Atomic Energy," "Isotopes" and "Atomic Effluent Disposal") will also be shown during the congress, which will meet on June 15. The exhibition will be held from June 14 to 21.

Hold-Up

According to 167 members of the American Atomic Industrial Forum, who replied to a questionnaire, the main factors delaying the development of nuclear power are: lack of economic incentive, lack of insurance and indemnification protection (the United States Government has in fact now offered indemnification to supplement private insurance as protection against nuclear accidents), secrecy and Government classification of technical information, lack of trained manpower, and Government administrative policies and practices.

Keeping it Dark

A statement on the tripartite declassification action referred to earlier in this article concludes with the following cryptic statement: "The Declassification Guide itself is a classified document because it enumerates categories of information that must, in the interest of national security, remain classified." The explanation is simple: those who know know, those who don't still don't.

In Parliament

LETTING THE RUSSIANS KNOW

Mr. David Ormsby-Gore, the Secretary of State for Foreign Affairs, had his attention drawn by Mr. Cyril Osborne (Conservative), in the House of Commons last week, to the publication recently started by the United States Government in Russia of an attractively-illustrated magazine, depicting the American way of life, for circulation in Moscow. This magazine, Mr. Osborne said, had a circulation of some 50,000 copies a month, and he urged that the British Government should take steps to have a similar journal issued about the English way of life. Mrs. Lena Jeger (Labour) pointed out that when the Foreign Office used to publish *Britansky Soyuzik* in Russian, it was very successful and used to sell 50,000 copies a week. She thought it a great pity that that publication had ever ceased.

Mr. Ormsby-Gore said that he was aware of the American undertaking and that the possibility of publishing a British periodical in the Russian language was under review by Dr. Charles Hill, the Chancellor of the Duchy of Lancaster, through his committee on overseas information. The previous British publication had run into very serious difficulties, as many members of the Opposition were aware.

WOMEN SCIENCE TEACHERS

More than 40 per cent. of women science graduates already enter the teaching profession. Further, the number of girls taking science subjects at the advanced level of the General Certificate of Education has increased rapidly in the last few years, and this, coupled with the expansion of the universities, should yield more science teachers. So far as non-graduates are concerned, Sir Edward Boyle, the Parliamentary Secretary to the Ministry of Education, said that more courses in science subjects were being provided in the teachers' training colleges. He told Mr. E. G. M. Fletcher (Labour), who raised the matter, that the programme of the Ministry of Education for supplementary courses was being expanded. During the present year, seven additional supplementary three-year courses, open to men and women non-graduates, would be arranged.

Later, Sir Edward informed Mr. John Hall (Conservative) that the Ministry had just received the report of the Committee on the Supply and Training of Teachers for Technical Colleges, presided over by Dr. Willis Jackson, F.R.S., M.I.E.E. The report was unanimous and it would be published as soon as possible.

SECRECY FOR STRIKE BALLOTS

Several questions have been put forward in the House recently suggesting that ballots for strike action should be held in secret. Last week Mr. W. Yates (Conservative) urged the Minister of Labour and National Service to introduce legislation to declare illegal lockouts or official strikes in cases where the employees involved had not had the opportunity of giving their personal decisions, free from duress, by secret ballot conducted by officials of the Ministry. Such a statute should provide that no illegal action should carry the right to benefit by way of tax or State assistance either to employer or worker.

Mr. Yates felt that this action would protect families and homes from the consequences of victimisation, either by employers or the trade unions, during industrial disputes. He pointed out that many people in Britain were seriously perturbed about this matter, both in regard to their own wages and the country's export trade. Consideration should be given as to whether the time had not arrived when a Royal Commission should be appointed to inquire into trade-union law in this country.

With respect to setting up a Royal Commission, Mr. Iain Macleod said that he had nothing to add to the answer he gave, on April 2, to a similar question, which was that legislation on these lines would not help to reduce the number of strikes. The present question related only to official strikes, and, of course, most strikes in Britain were unofficial. Such legislation would be quite ineffective. Mr. George Isaacs (Labour), a former Minister of Labour, intervened to ask how a secret ballot on a lockout could be instituted among employees and Mr. Macleod agreed that he had found that item in the question a puzzling one. Later, Mr. Macleod agreed to obtain for Captain H. B. Kerby (Conservative) information as to the practice obtaining in other countries, especially on such matters as to whether the laws were strictly enforced, and whether it was required that the ballots should be conducted by a returning officer independent of the union concerned.

RESTRICTIVE LABOUR PRACTICES

Another member, Mr. John Eden (Conservative), wanted the Minister of Labour to introduce legislation to enforce the registration of restrictive practices by trade unions. He hoped that Mr. Macleod would do what he could to persuade the unions to drop some of these futile, out-of-date practices, as well as " sending people to Coventry " and other forms of victimisation.

Mr. Macleod replied that restrictive labour practices were difficult to define, and that many of them were unwritten and matters of local custom. He did not think that registration would be a practicable proposition, but he recognised the importance of this problem. The National Joint Advisory Council of the Ministry was conducting an inquiry into the matter, with the object of securing a joint examination of restrictive labour practices in each industry.

Of course, it was true that there were restrictive practices on both sides of industry. To take a case which everybody had had very much in mind recently, all who had followed the inquiry into the shipbuilding dispute knew perfectly well that restrictive practices there were a very serious problem to that industry; again, perhaps, on both sides. So far as restrictive practices on the labour side of industry were concerned, he believed that real progress could be made only on the lines along which he was trying to proceed. The N.J.A.C. inquiry was beginning to produce results. Reports had already been received from committees set up in the industries covering the major proportion of workers in this country.

REAR-FACING SEATS IN AIRCRAFT

On the initiative of the United Kingdom, the Third Air Navigation Conference of the International Civil Aviation Organisation thoroughly examined the evidence for and against the installation of rearward-facing seating in aircraft but reached the conclusion that such seats should not be made an international requirement. Replying to a question on this subject, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, informed Air-Commodore A. V. Harvey (Conservative) that he did not consider that British operators should be required to provide seats of this description so long as their international contributors were not bound to do so. At the same time, British operators were free to provide rearward-facing seats if they so wished. Mr. Watkinson added that, in consultation with Mr. Aubrey Jones, the Minister of Supply, he was examining the possibilities of improving the design of forward-facing seats so as to minimise the risks of crash injury.

CHANNEL TUNNEL PROSPECTS

Asked by Dr. John Cronin (Labour) if he would make a statement regarding the England-to-France Channel Tunnel, Mr. Watkinson said that consideration was being given as to whether recent developments called for any change in policy. The present Government would not be particularly overawed at this stage by the advice given by General Sir Garnet Wolseley in the 1880s. As to a suggestion that any such scheme should include a road section as well as a railway section, which Mr. Gresham Cooke (Conservative), put forward, Mr. Watkinson said he would bear it in mind, but he must warn all concerned with this interesting and possibly desirable project that no plans had been found feasible so far for the inclusion of a road tunnel. It had to be borne in mind that a railway tunnel alone would probably cost about £100 million.

Oily-Water Separators

Mr. James Callaghan (Labour) asked what types of oily-water separators now available would be regarded as efficient under the regulations requiring dry-cargo ships to fit such apparatus by June 30, 1958. There was a certain amount of trepidation about the fact that time was running out and that a good deal of repair work would have to be done to ships before the scheme could be put into effect. Mr. Watkinson said that the regulations had not yet been made, although he was anxious to produce them as soon as possible. He was still discussing the regulations and the consequential arrangements with the shipping industry and the makers of separators.

Answering for Atomic Energy

Replying to a question by Sir John Crowder (Conservative) regarding ministerial functions in respect of atomic energy matters, Mr. Harold Macmillan, the Prime Minister, said that an Order in Council had been made transferring to him the functions formerly exercised by the Lord President of the Council in relation to atomic energy. Mr. Reginald Maudling, the Paymaster-General, would assist the Prime Minister in the discharge of these functions. Parliamentary questions should be addressed, Mr. Macmillan said, to him, and they would then be answered either by him or by Mr. Maudling according to circumstances.

Tendering for British-Type Jeeps

Captain H. B. Kerby (Conservative) wanted the Minister of Supply to name the manufacturers who refused to produce the Champ British-type Jeep for the army, " because of the radical departures from normal commercial practice in which they would otherwise have become involved." Mr. Aubrey Jones said that certain firms had declined to tender for the production of this Jeep because the work could not be accommodated with their other defence and export business, but four well-known firms did tender. It would be contrary to practice to disclose names.

Just Words

Mr. H. C. Usborne (Labour) asked the Foreign Secretary to explain what significance there was in the use by him of the words " treaty " and " pact," to describe the documents he signed when making agreements with the representatives of foreign countries. Mr. Ormsby-Gore replied that there was no particular significance in the use of these words. International compacts were sometimes termed not only treaties, or, in some instances, pacts, but also agreements, acts, conventions, and the like. There was no essential difference between these documents and their binding force upon the contracting parties was the same, whatever be their name. Mr. Usborne pointed out that, on occasion, international undertakings were also called " scraps of paper."

Unemployment Benefit for Non-Unionists

Difficulties arising from the payment of unemployment benefit were brought up by Mr. Cyril Osborne (Conservative). He pointed out that men who were not members of a trade union had been declared redundant by their employers because of recent strike action, and that these workers had been refused unemployment pay. Mr. John Boyd-Carpenter, Minister of Pensions and National Insurance, said he would be glad to examine any cases which Mr. Osborne cared to bring to his notice. The present rules relating to the payment of unemployment benefit during industrial disputes had been in operation since 1927, and subsequent reviews had not revealed any better alternative.

THE HUMAN ELEMENT

Birds of a Feather Work Together

Science is a hard taskmaster. Increasingly, industry's reliance on research teams is creating human problems more complex and even more difficult to solve than the scientific problems put to them. Extensive investigations of the composition of teams likely to produce the best results have been made in the United States by a Harvard psychologist, Dr. William C. Schutz. Dr. Schutz has found that small teams will work better together if their members are similar in their outlook than if they are complementary. For example, the more they share " a need to be liked," the more compatible they are likely to be " no matter what the kind of job may be for which the team is chosen."

Dr. Schutz reached his essentially simple conclusions through comprehensive personality studies, which began in 1952 under the aegis of the United States Navy. An account of the work and findings given in the issue of March 23 of *Business Week*, shows that he has carried out a three-way measurement of personality factors that he calls affection, independence, and inclusion. One of these " interpersonal needs " is generally dominant in most of us and is a major factor in determining our relationships with others in small group activities. " Affection involves the individual's need to be liked, his inclination to be genuinely friendly, overfriendly or unfriendly. Independence involves the strength of his desire for rule and authority and inclusion may be defined as the degree to which the individual feels other pepple are interested in him." All these are important and interrelated but the " need to be liked " plays the key role in group compatibility.

Much of Dr. Schutz's findings seem obvious enough, and are already well known. But the results he has obtained through experiments with compatible groups, for example those composed of people with similar psychological needs, show that immense scope exists for increasing the productivity of people, scientists and others, by careful selection of group members.

Lady on the Ladder

A booklet has been issued by the British Federation of University Women Limited called *Opportunities for Girls and Women in Science and Technology*. It is a comprehensive guide to careers in the professions and near-professional work like the Government service. It is a sign of the times that such a publication is necessary to advise girls and women that technical and scientific careers are now opening to them as well as administrative work.

It is inevitable that women have access to all the professions in the next generation or so. It is a national necessity if the requisite number of recruits are to be found for senior technical jobs in the atomic age. It is also the logical conclusion of the education system and its curricula which were established some eighty years ago. The social investment in education will at last begin to yield a full dividend. In a sense, the final opening of the professions to women is an easy intermediate stage. The difficult stages are when the pioneers take the opportunities in their grasp—which has now been largely done—and when the great bulk of the adjustments have to be made in industrial offices and the family as able women increasingly mix a career and marriage—a problem on a large scale which still lies ahead.

Come into my Parlour

The apprenticeship and trainee schemes at Metropolitan-Vickers have always been held in high regard in engineering. A period of training there has carried with it a certain hallmark. It is of particular interest therefore to see the trouble which the company is now taking to interest potential graduates in its training and career opportunities. This last is especially important for it is one thing to train men and another to be able to give them sufficient income and opportunity early enough to remove the danger of frustration.

At the beginning of this month the company held an " open week " when over 140 potential graduates of colleges and universities visited the works. These men had been seen earlier in the year in connection with the company's graduate training courses when senior members of the company's staff visited their colleges. This open week has given the men a chance to see for themselves and to go round and ask questions both about the training and the prospects. Clearly even the best companies with the best training reputations can no longer afford to rely solely on the " brochure " technique.

Three Questions for Scottish T.U.C.

The annual conference of the Scottish Trades Union Congress opened last week in full-blooded style. The opening day with its presidential address brought to the front three controversial issues all discussed in an argumentative frame of mind which left no doubt on which side of the border the conference was being held.

Mr. Frank Donachy in his presidential address called for an overhaul of the trade-union structure and where necessary for mergers, some of which he said were already being contemplated. He thought that trade-union organisation must keep up-to-date and not be tied to a system which had been devised to deal with the problems of the Nineteenth Century. This is a subject on which progressive trade unionists will follow him but it is one which it is easier to be objective about when somebody else's union is involved. Mr. Donachy went on to give a qualified endorsement of the European Common Market idea. Finally, he touched on a subject where feeling is strong among trade unionists in Scotland at present, namely, Scotland's need for further industrial diversification.

Altogether it was a rich diet to set before the conference and one on which the Communist-dominated Scottish Mineworkers' Union could give a standard performance of political partisanship. It will provoke heated argument for a long time, and more than that no one could ask from a presidential address—not even in Scotland.

Recruits for a Revolution

Some of the tasks that await the thousands of professional engineers we have yet to train were outlined by Dr. Willis Jackson recently at a meeting of the Engineers Guild in London. Dr. Jackson concentrated on the needs for electrical and electronics engineers needed to make possible the successful implementation of the nuclear energy programme, for the development of more efficient turbo-generators and to carry out the industrial revolution which began with the thermionic valve and the electronic computer.

The Institution of Electrical Engineers, said Dr. Jackson, has only 20,000 corporate members, representing a " total employment in all aspects of electrical engineering industry of about one million." Yet, increasingly the electrical industry's future progress depends on " the successful exploitation of the results of scientific research and invention," and this cannot be done without a much increased supply of " well educated and trained professional recruits."

Dr. Jackson called for a broader education up to the age of 17 or 18, and deplored the fact that in British schools the choice between a career in arts or science has to be made at the age of 14, which " is not satisfactory and does not meet present day needs." It is this need for a good general education as well as for good specialist training, which has so far been neglected in this country, far more than in either the United States or Russia. He added that recent publicity given to our shortcomings in training technologists had already begun to have an effect, and that there had been an abnormally high volume of applications for places in engineering schools this autumn.

Human Angle on Full Employment

At the recent British Institute of Management conference at Droitwich, Mr. S. C. Hills, regional secretary (Newcastle-upon-Tyne) Transport and General Workers' Union, gave a paper called " A Claim to be Treated as Human." Its theme was the need for management to take the workers into its confidence and not use such devices as joint consultation only as a means of paying lip-service to industrial co-operation when they can give so much better results when honestly worked. The days of hire and fire were over and the whole trend was to build up a stable labour force by pensions and so on, reducing the labour turnover and so doing away with a great deal of unnecessary industrial wastage.

This is indeed the trend and from most points of view it is a most desirable one. All the papers on this kind of subject, however, stop just when they are becoming interesting. How is this stability which is a fruit of full employment to be reconciled with the need for workers to change their jobs on occasion—whether they draw wages or a salary? It is when the argument comes up against this question that it becomes apparent that the question of employment security is as much a national economic question as the economics of full employment. The corollary to full employment is national pensions in the long run.

Briggs Postscript

The first of three courts of inquiry appointed to investigate troubles among engineering workers in recent weeks roundly condemns extremist activity in the trade unions. Lord Cameron's report on the Briggs dispute finds that the shop steward who called an unauthorised strike was properly dismissed and that the unions should not press further for his reinstatement. The unions should give immediate consideration to the form of organisation operated by the shop stewards at Briggs, " with a view to confining their activities within such limits as are strictly in accordance with the rules and constitution of their unions."

The Court find that a small nucleus of shop stewards, particularly A.E.U. stewards, caused most of the unrest at Briggs, and attribute their intransigence to a desire to retain power and independence from outside control. But the company come in for a good deal of criticism also. Three of the seven recommendations relate to desirable changes in the management's attitude. " Closer and more regular liaison with union representatives "; " consultation " on personnel management training " with a view to obtaining trade-union assistance " and " freer use of the Joint Works Committee " are all recommendations which point to the urgent need for more effective communications between managment and employees. The Court's findings are sensible and helpful, but it may well be that they have paid too little attention to informal relationships between the two sides, and therefore underestimated their crucial importance.